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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Bibliography 39-8

*Publications
of the
Jet Propulsion Laboratory
July 1966 through June 1967*

**JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA**

December 15, 1967


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Publications
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Jet Propulsion Laboratory
July 1966 through June 1967

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CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

December 15, 1967

Bibliography 39-8

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Foreword

JPL Bibliography 39-8 is a compilation of official reports of the Jet Propulsion Laboratory released July 1, 1966 through June 30, 1967. Current security classifications of all documents are indicated; however, their titles and abstracts given herein are unclassified. JPL reporting in the open literature is also included.

Jet Propulsion Laboratory reports may be requested by either entry or report number. When ordering classified documents, the government contract under which they will be used should be indicated, and requests forwarded to JPL via the cognizant contracting officer for certification of security clearance and "need-to-know." Copies of unclassified reports are available upon direct request to the Laboratory.

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Technical Reports and Memorandums

Technical Reports are designed to report on a single significant development, on the completion of a recognizable phase, or on the completion of an entire project, or may record data or a development growing out of an assigned project but not directly related to it.

Technical Memorandums report the results of a special study of a problem, provide preliminary information on a project, or present any other material which is intended for a limited audience.

Aller, L. H.

**A01 PHOTOELECTRIC SPECTROPHOTOMETRY OF
SELECTED SOUTHERN STARS**

Aller, L. H., Faulkner, D. J., Norton, R. H.

Technical Report 32-942 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 144,
No. 3, June 1966, pp. 1073-1100)

At Mount Stromlo Observatory and its Mount Bingar field station, spectral-energy distributions have been measured for a number of southern stars by comparing them with appropriate northern spectrophotometric-standard stars. The spectral traces, obtained with a scanner designed by Liller and equipped with a 1P21 photomultiplier tube, cover the wavelength range from 3400 to 5870 Å with a band pass of 10 Å. Since α Lyrae is not a satisfactory reference from the latitude of the Australian observatories, Oke's program star ξ^2 Ceti is chosen as the fundamental energy-distribution standard, and all observations are ultimately referred to it. Most of the data are handled by a spectrophotometric network, analogous to a triangulation network, the energy distributions, which are expressed as $m(1/\lambda)$, being smoothed at the last step. The accidental errors in the energy distributions amount to about ± 1 percent in the wavelength range 3600-5500Å; they are about ± 2 percent for $\lambda < 3600$ Å and ± 5 percent for $\lambda > 5500$ Å. Comparisons with the results obtained by Bahner, Code, and Oke for stars common to our list show generally good agreement except in the ultraviolet of α Leonis and 58 Aquilae.

Almaguer, T. A., Jr.

**A02 RANGER BLOCK III ATTITUDE CONTROL SYSTEM:
MANUFACTURING, TESTING AND PERFORMANCE**

Almaguer, T. A., Jr., Baxter, T. G., Hand, P. J.,

Perkins, G. S., Summers, R. H.

Technical Report 32-915, September 15, 1966
(Unclassified)

This Report, in conjunction with JPL Technical Report 32-663, forms a comprehensive documentation of the Block III attitude control system. Descriptions, requirements, test plans, and results of the attitude control system and the various sub-systems that comprise it are included.

Anderson, J. D.

**A03 DETERMINATION OF THE MASSES OF THE MOON
AND VENUS AND THE ASTRONOMICAL UNIT
FROM RADIO TRACKING DATA OF THE
MARINER II SPACECRAFT**

Anderson, J. D.

Technical Report 32-816, May 1, 1967

(Unclassified)

Doppler tracking data from the *Mariner II* spacecraft, which came within 41,000 km of Venus in December 1962, are used to obtain the mass of Venus and the astronomical unit. Also, a measure of the lunar inequality by means of the monthly periodic variation in the doppler curve permits a determination of the Earth-Moon mass ratio.

The method of data reduction is a least-squares differential correction of the spacecraft's orbit along with the three constants and several other parameters necessary to describe important non-gravitational forces. The geocentric location of the tracking stations and the heliocentric position of Venus are subject to correction also. Corrections for light-time, atmospheric refraction, and station timing are applied to the computed data.

The results indicate that the Sun-Venus mass ratio is 408505 ± 6 , the number of light seconds in one astronomical unit is 499.0036 ± 0.0017 sec, and the Earth-Moon mass ratio is 81.3001 ± 0.0013 . Information on the locations of the tracking stations and the direction and distance of Venus at the time of the encounter of *Mariner II* with the planet is also given.

**A04 TRAJECTORY DETERMINATION FROM
OBSERVATION DATA**

Anderson, J. D.

Technical Report 32-950 (Unclassified)

(Reprinted from "Recent Developments in Space Flight
Mechanics," *Science and Technology Series, American
Astronautical Society*, Vol. 9, 1966, pp. 132-158)

Descriptive in nature, this paper is intended primarily for the nonspecialist in the field of trajectory determination. A survey of techniques used to determine the trajectories of artificial celestial bodies from optical and radar observations is presented. Included are discussions of orbit computation methods, representation of data and the differential correction of orbits. The application of the differential correction process to the determination of astronomical constants and ephemerides is explained, and it is proposed that the radar tracking of spacecraft adds an important new tool to the field of observational astronomy. Examples are given of what has been accomplished with this tool to date, and also what can conservatively be expected from it in the future.

Anderson, T. O.

**A05 DEMONSTRATION OF A QUANTILE SYSTEM FOR
COMPRESSION OF DATA FROM DEEP SPACE
PROBES**

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.

Technical Report 32-772, Revision 1 (Unclassified)

(Reprinted from *IEEE Transactions on Aerospace and
Electronic Systems*, Vol. AES-3, No. 1, January 1967,
pp. 57-65)

This Report describes the theory and design of an advanced prototype of a quantile system of data compression for space telemetry. The basic idea is to transmit to Earth a few quantiles (or percentage points) of a histogram of experimental values formed aboard a spacecraft, then reconstruct on Earth a large part of the information that was contained in the original histogram. Compression ratios on the order of 100 to 1 are obtainable at 100 percent efficiency (in the sense of variances of estimates) with a simple device that performs no on-board arithmetic operations. An important feature of the quantile system is its self-adaptiveness. Examples are given of non-military and non-space applications. Experimental results obtained using the constructed system are presented.

Anderson, W. A.

**A06 INSTRUMENT FOR LUNAR SURFACE CHEMICAL
ANALYSIS**

Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A.,
Patterson, J. H., Franzgrote, E.

Technical Report 32-1065 (Unclassified)

(Reprinted from *The Review of Scientific Instruments*,
Vol. 37, No. 12, December 1966, pp. 1681-1686)

For abstract, see Turkevich, A.

Anspaugh, B. E.

**A07 HIGH-ENERGY PROTON TESTING
OF MARINER IV COMPONENTS**

Anspaugh, B. E.

Technical Memorandum 33-314, December 1, 1966
(Unclassified)

The following *Mariner IV* spacecraft components were irradiated with 20 to 137 Mev protons from the Harvard synchrocyclotron: (1) Canopus tracker, (2) data encoder, (3) squibs, (4) batteries, (5) solar cells, (6) central computer and sequencer circuitry, (7) Sun sensor, and (8) semiconductor devices and integrated circuits. All components, except the solar cells and Canopus tracker, operated normally during irradiation. The power output of the solar cells permanently dropped to 85% of the pre-irradiation value, but this was less than the predicted power loss. The tracker sensitivity was due to an induced radioactivity in the image dissector tube. The tracker lost roll control, but recovered tracking ability immediately when the beam was cut off. Consequently, a high-energy, high-intensity solar flare could degrade tracker operation to a marginal region, but the system would recover.

Argoud, M. J.

**A08 PRELIMINARY DESCRIPTION OF THE MODIFIED
JPL 25-ft SPACE SIMULATOR**

Argoud, M. J.

Technical Memorandum 33-319, February 1, 1967
(Unclassified)

The JPL 25-ft space simulator is designed for environmental testing of unmanned spacecraft under simulated interplanetary conditions of extreme cold, high vacuum, and intense solar radiation. Typical tests include heat balance and temperature distribution studies, investigations of subsystem interactions, tests of attitude-control equipment and sensors, and acceptance tests of flight spacecraft. A preliminary description of the facility, supporting systems, instrumentation systems, and design criteria is presented in this Memorandum.

Ash, G. R.

A09 A STUDY OF LOW-THRUST GUIDANCE

Ash, G. R.

Technical Report 32-1055, April 15, 1967 (Unclassified)

The low-thrust guidance problem is formulated. Approximate feedback solutions are obtained, using both minimum-time and least-squares criteria. Computer programs that simulate the resulting control systems are presented. Good performance is obtained with the minimum-time solution, and recommendations are made for future work on this problem.

The nonlinear, sequential estimation problem is considered, using the estimation equations obtained by Dr. R. Sridhar. A refinement of these equations is attempted, but the results are not encouraging. The computer programs used are presented, and recommendations are also made for continued work in this area.

Ashlock, J. C.

- A10 ON THE APPLICATION OF EXTREME-VALUE STATISTICS TO COMMAND ORIENTED PROBLEMS**
Ashlock, J. C., Lurie, S. M.
Technical Report 32-1025, October 15, 1966
(Unclassified)

When commanding planetary spacecraft, system constraints allow data rates of only a few bits per second. Also, the accuracy of received information must be high, since execution of an improperly received command could disrupt a mission. This Report considers the problem of experimentally estimating or verifying error probabilities when usage of the classical error-counting approach would be too time-consuming. The rudiments of extreme-value theory are introduced for the univariate case, where the bit-error probability of interest depends on a single variable, and for the bivariate case, where the bit-error probability is a function of two dependent variables. Examples of application and numerical results are presented, with considerable attention being given to techniques of implementing the theory.

Atkinson, G.

- A11 POLAR MAGNETIC SUBSTORMS**
Atkinson, G.
Technical Report 32-1094 (Unclassified)
(Reprinted from *Journal of Geophysical Research*,
Vol. 72, No. 5, March 1, 1967, pp. 1491-1494)

This Report develops the magnetic aspects of a theory of polar substorms that was presented in an earlier paper. The flow of flux tubes associated with a substorm is considered. It is suggested that the polar magnetic substorm current system is the superposition of the usual Hall current system and the westward electrojet, which is Pedersen current produced by the southward motion of field line across the high conductivity strip resulting from auroral deposition.

Back, L. H.

- B01 DETECTION OF OBLIQUE SHOCKS IN A CONICAL NOZZLE WITH A CIRCULAR-ARC THROAT**
Back, L. H., Cuffel, R. F.
Technical Report 32-1045 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 4, No. 12,
December 1966, pp. 2219-2221)

Characteristic predictions of supersonic flow through conical nozzles reveal shock formation where characteristics originating just downstream of the tangency between the conical divergent section and throat curvature section approach the nozzle axis. To detect this shock formation in a conical nozzle, measurements were made using a pitot tube and dried air at a stagnation temperature of 530°R and a stagnation pressure of 151 psia, with the nozzle discharging into the atmosphere. These measurements confirmed the existence of the predicted shock formation.

- B02 SOME OBSERVATIONS ON REDUCTION OF TURBULENT BOUNDARY-LAYER HEAT TRANSFER IN NOZZLES**

Back, L. H., Massier, P. F., Cuffel, R. F.
Technical Report 32-1056 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 4, No. 12,
December 1966, pp. 2226-2229)

This Report presents some results of experimental investigations of convective heat transfer in accelerated, heated air flows through cooled, conical, supersonic nozzles of three different configurations. It was found that a reduction of as much as 50% in heat transfer, below that typical of a turbulent boundary layer, occurs under certain conditions. This phenomenon, which occurs even though the boundary layer at the nozzle inlet is turbulent as determined from velocity distributions, has also been observed in rocket engine tests. The conditions for which this occurs appear to be related to convergent half-angle and the Reynolds number.

Bamford, R. M.

- B03 A MODAL COMBINATION PROGRAM FOR DYNAMIC ANALYSIS OF STRUCTURES**
Bamford, R. M.
Technical Memorandum 33-290, August 15, 1966
(Unclassified)

A method of determining the response of composite structures subjected to a sinusoidal forcing function is developed. The method uses characteristic rigid body and elastic deflected shapes of the components. The input required and limitations of a program using the method are stated. A sample problem is used to compare results with other methods.

Barath, F. T.

- B04 VENUS/MERCURY SWINGBY WITH VENUS CAPSULE: PRELIMINARY SCIENCE OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES**
Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S.,
Barath, F. T., Herriman, A. G., Goforth, L.
Technical Memorandum 33-332, May 1, 1967 (Unclassified)

For abstract, see Brereton, R. G.

Baxter, T. G.

- B05 RANGER BLOCK III ATTITUDE CONTROL SYSTEM: MANUFACTURING, TESTING AND PERFORMANCE**
Almaguer, T. A., Jr., Baxter, T. G., Hand, P. J.,
Perkins, G. S., Summers, R. H.
Technical Report 32-915, September 15, 1966
(Unclassified)

For abstract, see Almaguer, T. A., Jr.

Beaudet, R. A.

- B06 THE NUCLEAR MAGNETIC RESONANCE AND MICROWAVE SPECTRA OF SOME DEUTERIO DERIVATIVES OF 2,4-DICARBACLOVOHEPTA-BORANE(7)**
Onak, T., Dunks, G. B., Beaudet, R. A., Poynter, R. L.
Technical Report 32-1038 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 88, No. 20, October 20, 1966, pp. 4622-4625)

For abstract, see Onak, T.

Beer, R.

- B07 DECREMENT OF THE SOLAR CONTINUUM IN THE FAR INFRA-RED**
Beer, R.
Technical Report 32-929 (Unclassified)
(Reprinted from *Nature*, Vol. 209, No. 5029, March 19, 1966, p. 1226)

Some previous absolute measurements of the solar brightness temperature in the infra-red indicated that the Sun is deficient in infra-red radiation. A Michelson interference spectrometer was constructed to observe the far infra-red solar spectrum from a balloon, and the experiment was flown from Holloman Air Force Base, New Mexico. The experiment was only partially successful, but results supported the idea that the Sun is deficient in infra-red radiation. A first approximation to a power law for the decrement of the solar continuum in the far infra-red was computed.

- B08 WAVEFRONTS AND CONSTRUCTION TOLERANCES FOR A CAT'S-EYE RETROREFLECTOR**
Beer, R., Marjanemi, D.
Technical Report 32-983 (Unclassified)
(Reprinted from *Applied Optics*, Vol. 5, No. 7, July 1965, p. 1191)

A retroreflector (a device that reflects an incident beam of light through exactly 180°) constructed from a primary concave mirror and a small secondary mirror near its paraxial focus, the so-called *cat's-eye* retroreflector, has been investigated. Ray-tracing of systems with both spherical and parabolic primaries suggests that the latter are considerably superior to the former and comparable to a cube-corner retroreflector. The investigation has also enabled mechanical tolerances for the construction of a cat's-eye retroreflector to be deduced. The predicted tolerances may be much easier to attain than those for a cube-corner retroreflector.

Benedict, W. S.

- B09 TRACES OF HCl AND HF IN THE ATMOSPHERE OF VENUS**
Connes, P., Connes, J., Benedict, W. S., Kaplan, L. D.
Technical Report 32-1106 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 3, March 1967, pp. 1230-1237)

For abstract, see Connes, P.

Bernett, E. C.

- B10 EFFECTS OF DECONTAMINATION, STERILIZATION AND PRECONDITIONING TREATMENTS ON ENERGY-DISSIPATING PROPERTIES OF Balsa WOOD**
Bernett, E. C.
Technical Report 32-1022, November 1, 1966
(Unclassified)

The effect of various decontamination, sterilization, and preconditioning treatments on the energy-dissipating properties of balsa wood have been measured. The properties of as-received balsa wood were found to vary widely. Treatments of 5 hr at 260°C or 500 hr at 125°C caused significant degradation of the specific energy. Decreases to approximately 50% of the as-received value were measured. Other treatments did not have a serious effect on the specific energy, but did cause linear-dimension changes and variations in crushing stress that could be undesirable in some impact-limiting applications. Restrictive selection criteria may have to be established for the use of balsa wood as an energy-dissipating material.

Blake, F. A.

- B11 SOLAR PERFORMANCE EVALUATION TEST PROGRAM OF THE 9.5-ft-DIAM ELECTROFORMED NICKEL CONCENTRATOR S/N 1 AT TABLE MOUNTAIN, CALIFORNIA**
Blake, F. A.
Technical Memorandum 33-206, June 15, 1967
(Unclassified)

This Memorandum presents the results of the optical and calorimetric tests performed on 9.5-ft-diameter nickel mirrors obtained by electroforming the metal on a master produced by the spin-casting of epoxy plastic.

Blank, G. B.

- B12 DESERT ALGAE: SOIL CRUSTS AND DIAPHANOUS SUBSTRATA AS ALGAL HABITATS**
Cameron, R. E., Blank, G. B.
Technical Report 32-971, July 15, 1966
(Unclassified)

For abstract, see Cameron, R. E.

- B13 DESERT SOIL COLLECTION AT THE JPL SOIL SCIENCE LABORATORY**
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report 32-977, October 15, 1966
(Unclassified)

For abstract, see Cameron, R. E.

- B14 GROWTH OF AEROBIC AND ANAEROBIC BACTERIA IN AGAR SUBJECTED TO FREEZING AND DIURNAL FREEZING AND THAWING**
Cameron, R. E., Blank, G. B., Horowitz, N. H.
Technical Memorandum 33-331, June 15, 1967
(Unclassified)

For abstract, see Cameron, R. E.

Boggs, D.

**B15 COMPRESSED TRACKING DATA USED FOR FIRST
ITERATION IN SELENODESY EXPERIMENT,
LUNAR ORBITER I AND II**

Lorell, J., Sjogren, W. L., Boggs, D.
Technical Memorandum 33-343, May 1, 1967
(Unclassified)

For abstract, see Lorell, J.

Boundy, R. A.

**B16 POLYMERIC APPLICATIONS FOR THE MARINER
MARS, 1964 SPACECRAFT**

Freeman, R. F., Boundy, R. A., Harrington, R.
Technical Report 32-1031 (Unclassified)
(Reprinted from *Rubber and Plastic Age*, July 1966)

For abstract, see Freeman, R. F.

Bourke, R. D.

**B17 A METHOD FOR OBTAINING THE RADIUS
OF MARS**

Loomis, A. A., Bourke, R. D., DeBra, D. B.
Technical Report 32-1091 (Unclassified)
(Reprinted from *Journal of Geophysical Research*,
Vol. 72, No. 4, February 15, 1967, pp. 1265-1268)

For abstract, see Loomis, A. A.

Brennan, M.

**B18 STRUCTURE ANALYSIS AND MATRIX
INTERPRETIVE SYSTEM (SAMIS)
PROGRAM REPORT**

Melosh, R. J., Diether, P. A., Brennan, M.
Technical Memorandum 33-307, September 1, 1966
(Unclassified)

For abstract, see Melosh, R. J.

Brereton, R. G.

**B19 VENUS/MERCURY SWINGBY WITH VENUS
CAPSULE: PRELIMINARY SCIENCE OBJECTIVES
AND EXPERIMENTS FOR USE IN ADVANCED
MISSION STUDIES**

Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S.,
Barath, F. T., Herriman, A. G., Goforth, L.
Technical Memorandum 33-332, May 1, 1967
(Unclassified)

A Venus/Mercury swingby mission appears to be very desirable and practicable from the scientific point of view since it offers an unusual opportunity in an early mission to visit two planets and obtain data relating to a variety of scientific problems.

This Memorandum describes several possible scientific objectives, with their supporting experiments, for this type of

mission and also provides the scientific information for a preliminary mission study of a *Mariner*-type spacecraft to be flown via a close encounter with the planet Venus in a swingby trajectory by the planet Mercury during the 1970-1973 period.

**B20 VENUS: PRELIMINARY SCIENCE OBJECTIVES AND
EXPERIMENTS FOR USE IN ADVANCED
MISSION STUDIES**

(Revision 1)

Brereton, R. G., et al.

Technical Memorandum 33-282, August 1, 1966
(Unclassified)

This document reviews current knowledge about the planet Venus and describes several scientific objectives and supporting experiments for a 1500-lb *Mariner*-type spacecraft to be flown to the planet in the early 1970's. A combination flyby/capsule mission appears to best satisfy the scientific requirements for the mission.

**B21 MISSION TO A COMET: PRELIMINARY SCIENTIFIC
OBJECTIVES AND EXPERIMENTS FOR USE IN
ADVANCED MISSION STUDIES**

Brereton, R. G., Newburn, R. L., Giffin, C. E.,
Neugebauer, M. M., Smith, E. J., Willingham, D. E.
Technical Memorandum 33-297, February 15, 1967
(Unclassified)

Several possible scientific objectives for a comet mission and their supporting experiments are described. Background scientific information is also provided. An *Atlas/Centaur* launch vehicle is assumed, as is a spacecraft-comet encounter with a miss distance of less than 2500 km. A select list of scientific experiments on an intercept probe of this type can be expected to provide data contributing to a major advance in our understanding of comets. It is the thesis of this Memorandum that a space probe to a comet may be potentially the most important mission for purposes of cosmogonical research that will be feasible in the early 1970's.

Cameron, R. E.

**C01 DESERT ALGAE: SOIL CRUSTS AND DIAPHANOUS
SUBSTRATA AS ALGAL HABITATS**

Cameron, R. E., Blank, G. B.
Technical Report 32-971, July 15, 1966
(Unclassified)

In terrestrial desert environments, favorable microenvironments are found in the soil that promote the development of algae and associated organisms and a subsequent accumulation of organic matter. The most favorable habitats in desert soils occur in algal and lichen soil crusts, and on the undersurface of translucent or transparent materials partially imbedded in the soil surface. Algal abundance is increased and ecological factors are much less restrictive in these ecological niches over that in the surrounding desert soil. Insulation is modified, more moisture is retained, desiccation is reduced, and organic matter accumulations are noticeable. Characteristics of translucent

materials, such as white or milky quartz and chalcedony, which are partially imbedded in the surface of desert soils, permit the existence of mesophilic algal inhabitants, such as species of coccoid, blue-green algae, that do not normally occur as components of xeric soil populations. Other species are cosmopolitan forms occurring in a wide range of environments, including habitats at low or high elevations in hot or cold deserts. The probable occurrence of a number of translucent and transparent minerals in extraterrestrial soils and other geological materials may also provide a favorable ecological niche or microenvironment for organisms and associated organic matter in an otherwise harsh macroenvironment.

- C02 DESERT SOIL COLLECTION AT THE JPL SOIL SCIENCE LABORATORY**
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report 32-977, October 15, 1966
(Unclassified)

Desert soils and other geologic materials collected from 100 sites in desert regions comprise the Desert Soil Collection. Approximately 400 samples have been obtained from the surface to depths of 1 m since 1961, primarily from arid and semi-arid regions in the United States. Most of the samples are from California deserts. Additional samples have been obtained from arid or semi-arid regions of Baja California and Sonora, Mexico, several states of Argentina and Chile, and Egypt, U.A.R. A list of samples in the Collection is provided in this Report, along with descriptive information on the location and characteristics of the collection site, including photographs of the terrain and soil. Various NASA agencies and contractors have used soils in the Collection for test purposes in research related to extraterrestrial life detection, sampling, and harsh environmental studies. Some of the samples were taken from areas used subsequently for training U.S. astronauts for Moon exploration.

- C03 GROWTH OF AEROBIC AND ANAEROBIC BACTERIA IN AGAR SUBJECTED TO FREEZING AND DIURNAL FREEZING AND THAWING**
Cameron, R. E., Blank, G. B., Horowitz, N. H.
Technical Memorandum 33-331, June 15, 1967
(Unclassified)

Surface soils collected from nine sites were mixed and sieved to provide a composite soil sample. The abundance of aerobic and anaerobic bacteria in the sample was determined in trypticase soy agar plates subjected to temperature conditions of (1) room temperature, +25°C, (2) diurnal freezing, -75°C for 16 hr, and thawing, +25°C for 8 hr, and (3) continuous freezing at -75°C. Following two weeks of incubation at the above temperatures, all sets of agar plates were incubated for an additional two weeks at +25°C. Results show that the abundance of aerobes was greater than anaerobes; but after the second two weeks of incubation at room temperature, survival rates were comparable for sets of aerobic and anaerobic agar plates.

Campbell, B. A.

- C04 EFFECTS OF THE THERMAL STERILIZATION PROCEDURE ON POLYMERIC PRODUCTS**
Kalfayan, S. H., Campbell, B. A.
Technical Report 32-973, November 15, 1966
(Unclassified)

For abstract, see Kalfayan, S. H.

Capen, C. F.

- C05 THE MARS 1964-1965 APPARITION**
Capen, C. F.
Technical Report 32-990, December 15, 1966
(Unclassified)

A multicolor photographic and visual patrol of the planet Mars was carried out for an entire terrestrial year that covered the Martian northern hemisphere spring and summer during the 1964-1965 apparition. Good observational coverage was obtained of the *Mariner IV* spacecraft scan region (110-200° longitude) before, during, and after the photographic contact on July 15, 1965 UT. The nightly visual data greatly facilitated the reduction and analysis of the photographic record.

A daily observation report of surface conditions and atmospheric phenomena, a Mars pictorial atlas consisting of 358 drawings and photographs obtained during the 1964-1965 apparition, and *Mariner IV* photographic data are presented. A description is given of the surface features, seasonal changes, and secular changes observed during the Martian spring and summer. Atmospheric and meteorological observations are analyzed. The Martian polar regions are explored.

Carpenter, R. L.

- C06 STUDY OF VENUS BY CW RADAR - 1964 RESULTS**
Carpenter, R. L.
Technical Report 32-963 (Unclassified)
(Reprinted from the *Astronomical Journal*, Vol. 71, No. 2, March - No. 1337, 1966, pp. 142-152)

During the 1964 conjunction of Venus, the planet was observed by radar on a daily basis with an 85-ft dish at the NASA/JPL Deep Space Instrumentation Facility at Goldstone, California. The wavelength was 12.5 cm and the transmitter power was 100 kw. The results of one phase of the program are discussed - those of the high-resolution cw radar spectra. The polarized reflectivity obtained is 0.114 ± 0.01 . The depolarized reflectivity is 0.0067 ± 0.0005 . The estimated average dielectric constant of Venus' surface is 3.75 ± 0.3 . The base bandwidth of the spectra gives a retrograde sidereal rotation of 250 days +4, -7 days. The direction of the north polar axis is estimated to be $\bar{\alpha} = 255^\circ + 10^\circ$, -4° and $\delta = 68^\circ \pm 4^\circ$. This places the axis within 10° of the orbit pole. Several spectral features were found and their positions on Venus' surface is derived. A comparison of the 1964 features with the features observed in 1962 suggests that the rotation of Venus may be nearer to 244 days retrograde rather than 250 days given by the base bandwidth measurements.

Carroll, W.

**C07 MARINER MARS 1964 TEMPERATURE CONTROL
HARDWARE DESIGN AND DEVELOPMENT**

Carroll, W., Coyle, G. G., Delden, von H.
Technical Report 32-955, June 1, 1967
(Unclassified)

The temperature control system on the *Mariner* Mars 1964 spacecraft is described. The evolution of the design is traced from inception to final configuration. The criteria for selecting surface finishes and materials are discussed in relation to spacecraft requirements and space-simulator testing conditions. Recommendations are made that may be applicable to the design of temperature control hardware for future projects.

Chamberlain, R. G.

**C08 SEPARATION OF TWO BODIES IN SPACE –
A MACHINE PROGRAMMED ANALYSIS USING THE
LAGRANGE EQUATIONS AND EULERIAN ANGLES**

Mack, T. H., Chamberlain, R. G.
Technical Report 32-912, May 15, 1966
(Unclassified)

For abstract, see Mack, T. H.

C09 A SPACE MISSION SUCCESS EVALUATION MODEL
Chamberlain, R. G.

Technical Report 32-961, October 15, 1966
(Unclassified)

High among the considerations involved in the planning of space missions is the probable success of the mission. The determination of this value can lead to answers to such important questions as: (1) Is the probable return sufficiently high to justify the planned allocation of resources and is the risk (probability of an insufficient return) satisfactorily low? (2) How should the currently available resources be allocated to maximize the probable success? (3) Which of the multitude of possible changes in design will give the greatest increase in probable return for the least expenditure of additional resources? The approach presented shows a technique for determining a quantitative measure of success, a procedure for evaluating this measure both *a priori* and *a posteriori*, a systematic technique for collecting and displaying the necessary input information, and a method for determining the optional allocation of resources.

**C10 THE VOYAGER PLANETARY QUARANTINE MODEL
1973 MISSION**

Chamberlain, R. G.
Technical Memorandum 33-252, June 1, 1967
(Unclassified)

This Memorandum presents the framework of a model which treats all elements of the *Voyager* 1973 mission in sufficient detail to allow reasonable assurance that the *Voyager* policy on planetary quarantine can and will be adhered to by the *Voyager* Project.

The *Voyager* 1973 mission is examined from the point of view of planetary quarantine in order to isolate every conceivable source of contamination of the planet Mars. These sources are being studied in detail to ascertain the requirements that must be met by the hardware and mission designs in order to satisfy the constraints imposed by the planetary quarantine policy.

Chapman, C. P.

**C11 A POWER-SPECTRAL-DENSITY COMPUTER
PROGRAM FOR THE VIBRATION LABORATORY**

Chapman, C. P.
Technical Report 32-993, August 1, 1966
(Unclassified)

This Report presents the considerations for, descriptions of, results from, and summary of the computer program written by the Environmental Laboratory personnel at JPL.

The computer program calculates vibration-acceleration densities (g^2/cps) at particular frequencies along power-spectral density (PSD) plots, and root-mean-square (r_{rms}) acceleration (g_{rms}) across the PSD-frequency spectra of random-noise test specifications. The most significant advantage of this computer program is its complete generality. It can be used to calculate g^2/cps and g_{rms} over any PSD specification without modification; only the data cards have to be changed. The output data from the computer program are used to verify the specification test levels and provide the theoretical PSD to obtain a spectra ratio for purposes of analysis on completion of the vibration test. The results of the vibration test can then be displayed on a graph that illustrates in db the deviation from the specified g^2/cps at any frequency within the test-frequency spectrum.

Charles, F. J.

**C12 A MODEL DISTRIBUTION FOR THE PHASE ERROR
IN SECOND-ORDER PHASE-LOCKED LOOPS**

Lindsey, W. C., Charles, F. J.
Technical Report 32-1017 (Unclassified)
(Reprinted from *IEEE Transactions on Communication Technology*, Vol. COM-14, No. 10, October 1966, pp. 662-664)

For abstract, see Lindsey, W. C.

**C13 SOME ANALYTICAL AND EXPERIMENTAL
PHASE-LOCKED LOOP RESULTS FOR LOW
SIGNAL-TO-NOISE RATIOS**

Charles, F. J., Lindsey, W. C.
Technical Report 32-1027 (Unclassified)
(Reprinted from the *Proceedings of the IEEE*, Vol. 54, No. 9, September 1966, pp. 1152-1166)

This paper is concerned with the nonlinear behavior of the second-order phase-locked loop (PLL) in the presence of noise. The loop filter, a proportional-plus-integral control type, corresponds to the one generally employed for carrier track-

ing purposes in the implementation of phase-coherent communication systems. Since the analytical results presented pertain to the probability distribution of the phase error and are approximations valid only for certain regions of signal-to-noise ratio, they are complemented by experimental results obtained from simulation of the PLL system in the laboratory. The experimental techniques used to measure the statistical properties of the loop behavior and the corresponding results are discussed.

Approximate analytical expressions for the distribution of the system phase error are first obtained by using the Fokker-Planck apparatus and, secondly, by assuming that the PLL behaves as a very narrow band-pass filter. The range of signal-to-noise ratios for which these approximations are valid is obtained by graphically comparing the analytical expressions to experimentally derived phase-error distributions. In addition, measurements relative to the variance of the phase error are compared to those predicted by the linear PLL theory and the variance as computed from the approximate solutions. Finally, experimental results relative to the probability distribution of the time intervals between cycle-slipping events are given for signal-to-noise ratios in a range where the linear PLL theory does not apply. In particular, the maximum length of time the loop may be expected to remain in-lock is illustrated graphically as a function of signal-to-noise ratio in the loop bandwidth.

Chelson, P. O.

C14 RELIABILITY MATH MODELING USING THE DIGITAL COMPUTER

Chelson, P. O.

Technical Report 32-1089, April 15, 1967
(Unclassified)

A computer program is presented to calculate probability of system success from an arbitrary reliability block diagram utilizing the IBM 1620. The program uses an algorithm that was developed by using the probability tree method of calculating system success. The mechanics of the program are such that during execution it is possible to vary the probability of success as well as the arrangement of the blocks in the diagram to determine which combination has the greatest effect on the total reliability of the system.

Chen, C. J.

C15 VELOCITY-PROFILE MEASUREMENT IN PLASMA FLOWS USING TRACERS PRODUCED BY A LASER BEAM

Chen, C. J.

Technical Report 32-989 (Unclassified)
(Reprinted from *Journal of Applied Physics*, Vol. 37, No. 8, July 1966, pp. 3092-3095)

A giant pulse laser is focused in a gas flow by a lens. The plasma drop produced by the gas breakdown is used as a tracer for the flow velocity measurement. The motion of the plasma

drop is detected by both electrostatic probe and drum-camera techniques. The estimated experimental error in the present setup is about 3 percent. The new features of this method are (1) very high spatial resolution, (2) minimum disturbance in the flow due to the instrumentation, and (3) applicability both to un-ionized and ionized flows.

Choate, R.

C16 LUNAR SLOPE ANGLES AND SURFACE ROUGHNESS FROM RANGER PHOTOGRAPHS

Choate, R.

Technical Report 32-994 (Unclassified)

(Reprinted from the *Proceedings of the Fourth Symposium on Remote Sensing of Environment*, University of Michigan, Ann Arbor, June 1966, pp. 411-432)

Many published estimates of large slope angles of lunar craters in late P-frame *Ranger VII* and *VIII* photographs are in error because they were based in part on interpretation of the dark areas in the craters as being shadows. Recent work at JPL demonstrates that most slopes in *Ranger* impact areas have small angles, and that most craters have uniform slopes with a short, nearly horizontal, central portion and gently rounded rims. Slope angle, local relief, and surface roughness indicate that topography in *Ranger VII*, *VIII*, and *IX* impact areas probably developed from the same geomorphic process and is at or near equilibrium.

Christiansen, H. N.

C17 STRUCTURAL ANALYSIS AND MATRIX INTERPRETIVE SYSTEM (SAMIS) PROGRAM: TECHNICAL REPORT

Melosh, R. J., Christiansen, H. N.

Technical Memorandum 33-311, November 1, 1966
(Unclassified)

For abstract, see Melosh, R. J.

Clauss, R. C.

C18 A TRAVELING WAVE MASER FOR DEEP SPACE COMMUNICATION AT 2295 AND 2388 MHZ

Clauss, R. C.

Technical Report 32-1072, February 15, 1967
(Unclassified)

A tunable traveling wave maser has been used for deep space communications at 2295 MHz and for planetary radar experiments at 2388 MHz. Machining techniques have been developed that enable a comb-structure maser to be fabricated from a single piece of copper. Excellent surface finish and close tolerances result in low loss at the signal frequency. Gain adjustment trim coils are used to trade gain for additional bandwidth. An external overcoupled cavity is used with the pump klystron to provide pump power for operation at a signal frequency of either 2295 or 2388 MHz. The maser operates in a closed-cycle helium refrigerator at 4.4°K, and refrigeration is also used to cool the signal input coaxial transmission line. An

in-line quarter-wave thermal short circuit is used to transfer heat from the coaxial center conductor. This has reduced the equivalent input noise temperature of the maser to 5°K.

Clayton, R. M.

- C19 AN EXPERIMENTAL CORRELATION OF THE NONREACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE PART II. INSTRUMENTATION, EXPERIMENTAL APPARATUS, AND EXPERIMENTAL TECHNIQUES**
Clayton, R. M., Rupe, J. H., Gerbracht, F. G.
Technical Report 32-255, May 15, 1967 (Unclassified)

The details of the experimental apparatus, techniques, and instrumentation for an injection research program utilizing several 20,000-lbf-thrust rocket engines are given. The objectives of the program required the comparison of thermochemical performance, heat transfer, and combustion roughness behavior yielded by nine different injector designs; hence, the interest in accurate measurements was paramount. Following a description of the procedures and equipment, estimates of the achieved accuracies are presented based on a statistical analysis.

Connes, J.

- C20 NEAR-INFRARED PLANETARY SPECTRA BY FOURIER SPECTROSCOPY. I. INSTRUMENTS AND RESULTS**
Connes, J., Connes, P.
Technical Report 32-980 (Unclassified)
(Reprinted from *Journal of the Optical Society of America*, Vol. 56, No. 7, July 1966, pp. 896-910)

A near-infrared, two-beam interferometer has been built for astronomical observations by Fourier transform spectroscopy. Various improvements, especially a highly accurate interferometrically controlled stepping drive, have resulted in the production of laboratory spectra with 0.1-cm⁻¹ resolution and unusually clean instrumental line shape, and spectra of Venus and Mars with about 1-cm⁻¹ resolution.

- C21 MARS: NEW ABSORPTION BANDS IN THE SPECTRUM**
Connes, J., Connes, P., Kaplan, L. D.
Technical Report 32-996 (Unclassified)
(Reprinted from *Science*, Vol. 153, No. 3737, August 1966, pp. 739-740)

New absorption bands have been found in the near-infrared spectrum of Mars by Fourier spectroscopy. They are tentatively identified in part as due to reduced gases in the Martian atmosphere. The purpose of the Report is: (1) to call attention to the success of interferometry in obtaining spectra of planets with sufficient resolution in the PbS region to resolve rotational fine structure, and (2) to note the presence of constituents in the Martian atmosphere that may have important implications regarding the possibility and the nature of life on Mars.

- C22 PLANETARY SPECTRA BY FOURIER SPECTROSCOPY I: MARS**
Connes, P., Connes, J.
Technical Report 32-998, August 1, 1966
(Unclassified)

For abstract, see Connes, P.

- C23 TRACES OF HCl AND HF IN THE ATMOSPHERE OF VENUS**
Connes, P., Connes, J., Benedict, W. S., Kaplan, L. D.
Technical Report 32-1106 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 3, March 1967, pp. 1230-1237)

For abstract, see Connes, P.

Connes, P.

- C24 NEAR-INFRARED PLANETARY SPECTRA BY FOURIER SPECTROSCOPY. I. INSTRUMENTS AND RESULTS**
Connes, J., Connes, P.
Technical Report 32-980 (Unclassified)
(Reprinted from *Journal of the Optical Society of America*, Vol. 56, No. 7, July 1966, pp. 896-910)

For abstract, see Connes, J.

- C25 MARS: NEW ABSORPTION BANDS IN THE SPECTRUM**
Connes, J., Connes, P., Kaplan, L. D.
Technical Report 32-996 (Unclassified)
(Reprinted from *Science*, Vol. 153, No. 3737, August 1966, pp. 739-740)

For abstract, see Connes, J.

- C26 PLANETARY SPECTRA BY FOURIER SPECTROSCOPY I: MARS**
Connes, P., Connes, J.
Technical Report 32-998, August 1, 1966
(Unclassified)

Mars spectra, obtained during the spring 1965 apparition by interferometric spectroscopy, are presented. A brief discussion is included, together with a summary of the format used to characterize the individual spectral traces. Tables, covering the observing conditions at the time the spectra were taken, are also included.

- C27 TRACES OF HCl AND HF IN THE ATMOSPHERE OF VENUS**
Connes, P., Connes, J., Benedict, W. S., Kaplan, L. D.
Technical Report 32-1106 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 3, March 1967, pp. 1230-1237)

High-resolution interferometric spectra of Venus show weak, narrow absorption lines which are assigned to the 2-0 vibration-rotation band of HCl and the 1-0 and 2-0 bands of HF. The HCl lines are consistent with 2-mm Amagat of that gas in

the optical path, at temperatures near 240°K and pressure near 0.1 atm, in a spectral region where the effective CO₂ path is 1.7×10^6 times as large. The less-extensive HF data indicate about 0.02-mm Amagat of that gas.

Coyle, G. G.

- C28 **MARINER MARS 1964 TEMPERATURE CONTROL
HARDWARE DESIGN AND DEVELOPMENT**
Carroll, W., Coyle, G. G., Delden, von H.
Technical Report 32-955, June 1, 1967
(Unclassified)

For abstract, see Carroll, W.

Cuddihy, E. F.

- C29 **EFFECT OF POLAR FORCES ON THE
VISCOELASTIC PROPERTIES OF POLY
(PROPYLENE OXIDE)**
Moacanin, J., Cuddihy, E. F.
Technical Report 32-1026 (Unclassified)
(Reprinted from *Journal of Polymer Science: Part C*,
No. 14, 1966, pp. 313-322)

For abstract, see Moacanin, J.

Cuffel, R. F.

- C30 **DETECTION OF OBLIQUE SHOCKS IN A CONICAL
NOZZLE WITH A CIRCULAR-ARC THROAT**
Back, L. H., Cuffel, R. F.
Technical Report 32-1045 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 4, No. 12,
December 1966, pp. 2219-2221)

For abstract, see Back, L. H.

- C30 **SOME OBSERVATIONS ON REDUCTION OF
TURBULENT BOUNDARY-LAYER HEAT TRANSFER
IN NOZZLES**
Back, L. H., Massier, P. F., Cuffel, R. F.
Technical Report 32-1056 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 4, No. 12,
December 1966, pp. 2226-2229)

For abstract, see Back, L. H.

Cutting, E.

- C31 **TRAJECTORY ANALYSIS OF A 1970 MISSION TO
MERCURY VIA A CLOSE ENCOUNTER WITH
VENUS**
Sturms, F. M., Jr., Cutting, E.
Technical Report 32-943 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, Vol 3,
No. 5, May 1966, pp. 624-631)

For abstract, see Sturms, F. M., Jr.

Davis, D. P.

- D01 **PRELIMINARY EVALUATION OF G-11 AND
G-16 PERCUSSION PRIMERS**

Davis, D. P.

Technical Memorandum 33-308, December 15, 1966
(Unclassified)

Percussion primers, like those usually used in rifle ammunition, can be used to initiate certain pyrotechnic devices on spacecraft, such as parachute reefing line cutters. Most of these primers quickly deteriorate in elevated temperatures and will not meet the JPL *Voyager* capsule thermal sterilization requirement. However, two percussion primers, designated G-11 and G-16, will apparently withstand sterilizing temperatures. Tests to obtain information on seven characteristics of the G-11 and G-16 primers indicated that these primers would meet the special requirements of the *Voyager* capsule.

Davis, J. P.

- D02 **LITHIUM-BOILING POTASSIUM TEST LOOP
INTERIM REPORT**

Kikin, G. M., Davis, J. P., Griffin, D. C., Peelgren, M. L.,
Phillips, W. M.

Technical Report 32-1083, September 15, 1966
(Unclassified)

For abstract, see Kikin, G. M.

DeBra, D. B.

- D03 **A METHOD FOR OBTAINING THE RADIUS OF
MARS**

Loomis, A. A., Bourke, R. D., DeBra, D. B.

Technical Report 32-1091 (Unclassified)
(Reprinted from *Journal of Geophysical Research*,
Vol. 72, No. 4, February 15, 1967, pp. 1265-1268)

For abstract, see Loomis, A. A.

Delden, von H.

- D04 **MARINER MARS 1964 TEMPERATURE CONTROL
HARDWARE DESIGN AND DEVELOPMENT**

Carroll, W., Coyle, G. G., Delden, von H.

Technical Report 32-955, June 1, 1967
(Unclassified)

For abstract, see Carroll, W.

DeMore, W. B.

- D05 **NEW MECHANISM FOR OH-CATALYZED CHAIN
DECOMPOSITION OF OZONE**

DeMore, W. B.

Technical Report 32-1063 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*,
Vol. 46, No. 2, January 15, 1967, pp. 813-814)

There is good evidence that OH radicals are involved in a

catalyzed chain decomposition of O_3 . However, mechanisms proposed by Norrish and Kaufman do not explain the OH-catalyzed chains under all conditions. A new mechanism is proposed which, together with the Kaufman mechanism, explains the chain decomposition completely.

Deo, N.

D06 THE SELF-DIAGNOSABILITY OF A COMPUTER

Deo, N.

Technical Report 32-1040 (Unclassified)

(Reprinted from *IEEE Transactions and Electronic Computers*, Vol. EC-15, No. 5, October 1966, p. 799)

A self-diagnosable computer may be described as a system of two interconnected but independent machines: the main processor and a much smaller machine capable of program-matically detecting and locating a fault in the main processor. This fault location should be pinpointed within a small number of replaceable modules (integrated circuit chips, parallel-plate packages, or printed circuit cards). The maximum capability for self-diagnosis with minimum additional hardware is the goal of every designer of a general-purpose computer. A means by which the self-diagnosability of a system can be measured is proposed in this Report.

D07 PARTIAL VERSUS TOTAL REDUNDANCY

Deo, N.

Technical Report 32-1088 (Unclassified)

(Reprinted from *Electronics Letters*, Vol. 3, No. 1, January 1967)

Contrary to common belief, one can achieve better reliability by triplicating only part of a computing machine rather than by triplicating the whole machine. The reliability figures for varying degrees of partial redundancy have been obtained. From such figures are derived conditions best suited to the totally redundant, partially redundant, or nonredundant system.

Diether, P. A.

D08 STRUCTURAL ANALYSIS AND MATRIX INTERPRETIVE SYSTEM (SAMIS) PROGRAM REPORT

Melosh, R. J., Diether, P. A., Brennan, M.

Technical Memorandum 33-307, December 15, 1966 (Unclassified)

For abstract, see Melosh, R. J.

Dobbins, R. A.

D09 RECENT MEASUREMENTS AT JPL OF PARTICLE SIZE OF Al_2O_3 FROM SMALL ROCKET MOTORS

Dobbins, R. A., Strand, L. D.

Technical Memorandum 33-352, June 15, 1967 (Unclassified)

This second series of 28 test firings was a continuation of

a program to determine the particle size of Al_2O_3 from small rocket motors. After modifications were made to the emission-scattering photometer, the tests were conducted with varying amounts of aluminum, with optical beam geometry variations, and with the new infrared channel. Results of the tests with varying amounts of aluminum agreed with the 1964 results. Results of the tests with various radial positions indicated that the particle size did not vary in relation to radial positions. Results of the new infrared channel tests are inconclusive until further computer analysis can be conducted. The particle recovery tests are presently being conducted to determine whether the particle size distributions are dependent upon the receiver tank size.

Drummond, A. J.

D10 PYRHELIOMETRIC COMPARISONS AT THE JPL TABLE MOUNTAIN FACILITY

Drummond, A. J., Laue, E. G.

Technical Memorandum 33-312, December 15, 1966 (Unclassified)

A series of comparative measurements of various pyrhe-liometric instruments was made using natural sunlight at the JPL Table Mountain Facility. This Report presents details of the measurements, introduces instrument calibration techniques for flight and surface radiometers, and describes the methods of observation.

DSN Staff

D11 DESCRIPTION OF THE DEEP SPACE NETWORK OPERATIONAL CAPABILITIES AS OF JANUARY 1, 1966

Technical Memorandum 33-255, July 1, 1966 (Unclassified)

The Deep Space Network (DSN) is a facility of the National Aeronautics and Space Administration (NASA) Office of Tracking and Data Acquisition, under the system management and technical direction of the Jet Propulsion Laboratory (JPL), California Institute of Technology. The DSN is capable of two-way communications with, and has the tracking and data-handling equipment to support, unmanned spacecraft traveling approximately 10,000 mi from Earth to interplanetary distances.

The main elements of the DSN are the Deep Space Instrumentation Facility (DSIF), the Ground Communications System (GCS) and the Space Flight Operations Facility (SFOF).

The DSIF consists of a network of tracking and communication stations situated so that three stations may be selected approximately 120 deg apart in longitude in order that a spacecraft in or near the ecliptic plane is always within the field of view of at least one of the selected ground antennas.

The GCS consists of voice, teletype and high speed data circuits provided by the NASA World Wide Communications Network between each overseas station, Cape Kennedy and the SFOF. Voice, teletype, high speed data and video circuits

between the SFOF and the Goldstone Stations are provided by a DSN microwave link.

The SFOF is located at JPL and is the focal point of the DSN systems. The SFOF contains operations control consoles, status and operations displays, computers and data processing equipment for analysis of spacecraft performance and space science experiments, and communication facilities to control space flight operations.

Dunks, G. B.

- D12 THE NUCLEAR MAGNETIC RESONANCE AND MICROWAVE SPECTRA OF SOME DEUTERIO DERIVATIVES OF 2,4-DICARBACLOVOHEPTABORANE(7)**
Onak, T., Dunks, G. B., Beaudet, R. A., Poynter, R. L.
Technical Report 32-1038 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 88, No. 20, October 20, 1966, pp. 4622-4625)

For abstract, see Onak, T.

Eddington, R. B.

- E01 INVESTIGATION OF SUPERSONIC SHOCK PHENOMENA IN A TWO-PHASE (LIQUID-GAS) TUNNEL**
Eddington, R. B.
Technical Report 32-1096, March 15, 1967
(Unclassified)

Homogeneous two-phase flows of dispersed liquid and gas at velocities in excess of the local velocity of sound can produce shock phenomena similar to that experienced in supersonic gaseous media. A supersonic two-phase tunnel was designed and built so that normal and oblique shock structures can be photographed and analyzed in the absence of boundary-layer interference. Auxiliary flow devices were constructed for the measurement of such difficult flow parameters as the relative phase velocity, local void ratio, coefficient of friction, and stagnation pressure. Considerable photographic information pertaining to shock structure and phase movement was obtained over the spectrum of flow conditions with Mach numbers ranging from 2 to 20.

Eisenberger, I.

- E02 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES (REVISION 1)**
Anderson, T. O., Eisenberger, I., Lushbaugh, W. A., Posner, E. C.
Technical Report 32-772 (Unclassified)
(Reprinted from *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-3, No. 1, January 1967, pp. 57-65)

For abstract, see Anderson, T. O.

Elleman, D. D.

- E03 NUCLEAR MAGNETIC RESONANCE OF PHOSPHORUS COMPOUNDS. II. THE RELATIVE SIGNS OF THE SPIN-SPIN COUPLINGS IN DIMETHYLPHOSPHINE AND METHYLPHOSPHINE**
Manatt, S. L., Juvinall, G. L., Wagner, R. I., Elleman, D. D.
Technical Report 32-974 (Unclassified)
(Reprinted from *Journal of the American Chemical Society*, Vol. 88, No. 12, June 20, 1966, pp. 2689-2697)

For abstract, see Manatt, S. L.

Emmert, R. A.

- E04 INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS**
Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A., Patterson, J. H., Franzgrote, E.
Technical Report 32-1065 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 12, December 1966, pp. 1681-1686)

For abstract, see Turkevich, A.

Faulkner, D. J.

- F01 PHOTOELECTRIC SPECTROPHOTOMETRY OF SELECTED SOUTHERN STARS**
Aller, L. H., Faulkner, D. J., Norton, R. H.
Technical Report 32-942 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 144, No. 3, June 1966, pp. 1073-1100)

For abstract, see Aller, L. H.

Feitis, P. H.

- F02 TRAJECTORY DESIGN FOR IMPULSIVE EARTH-MARS-EARTH TRAJECTORIES LAUNCHED IN 1969 AND 1971**
Feitis, P. H.
Technical Report 32-1007, December 1, 1966
(Unclassified)

This Report discusses the trajectory design for a spacecraft which returns to the vicinity of the Earth after a Mars encounter. The method and associated computer programs used to analyze the Earth-Mars-Earth trajectories based on the patched conic model are described, as are communications advantages of such an Earth-Mars-Earth mission.

It is possible to fly a purely ballistic round-trip mission to Mars and back with a relatively short flight time. A wide variety of encounter geometries at Mars is possible, some of which are suitable for television pictures and other scientific experiments. If it is necessary to carry out a velocity correction maneuver at Mars due to a difference in asymptote of approach and departure, the round-trip trajectory is called "impulsive." By using a velocity increment, it is often possible to improve the trajectory characteristics or mission payload. It has been concluded that the 1971 Earth-to-Mars launch period is more advantageous for Earth-return missions than the 1969, 1973, and 1975 Mars opportunities.

F03 1972 EARTH-VENUS TRAJECTORIES

Feitis, P. H.

Technical Memorandum 33-334, January 15, 1967

(Unclassified)

Results are presented of an analysis of Earth-Venus trajectories for spacecraft launched during the favorable launch period occurring in 1972. The data are based on the patched-conic approximation; i.e., the Earth-Venus trajectory consists of three distinct phases of two-body motion: (1) an escape hyperbola near Earth, (2) an elliptical motion with respect to the Sun, and (3) a hyperbolic trajectory near Venus. Extensions of previously reported data for the Venus opportunities occurring between 1962 and 1970 are also included. Future reporting will cover the 1973, 1975, 1976, 1978, and 1980 Venus opportunities.

F04 1973 EARTH-VENUS TRAJECTORIES

Feitis, P. H.

Technical Memorandum 33-342, February 28, 1967

(Unclassified)

Results are presented of an analysis of Earth-Venus trajectories for spacecraft launched during the favorable launch period occurring in 1973. The data are based on the patched-conic approximation; i.e., the Earth-Venus trajectory consists of three distinct phases of two-body motion: (1) an escape hyperbola near Earth, (2) elliptical motion with respect to the Sun, and (3) a hyperbolic trajectory near Venus. Extensions of previously reported data for the Venus opportunities occurring between 1962 and 1972 are also included. Future reporting will cover the 1975, 1976, 1978, and 1980 Venus opportunities.

Fischbach, D. B.**F05 PREFERRED ORIENTATION PARAMETERS FOR PYROLYTIC CARBONS**

Fischbach, D. B.

Technical Report 32-936 (Unclassified)

(Reprinted from *Journal of Applied Physics*, Vol. 37, No. 5, April 1966, pp. 2202-2203)

Pyrolytic carbons (also called pyrolytic graphites) exhibit a pronounced orientation texture in which the c axes of the crystallites tend to lie perpendicular to the surface of the substrate on which the deposit is formed. The degree of preferred orientation (PO) depends on deposition conditions and on subsequent mechanical and thermal treatment at high temperatures. In as-deposited and in heat-treated flat plates, the orientation texture is isotropic in the plane of the deposit, but this is not necessarily true of deformed samples. A number of papers have reported investigations of the PO in pyrolytic carbons. In general, the same x-ray technique for obtaining the orientation distribution function has been used. However, a variety of different parameters have been employed to characterize the observed distribution, making comparison of results difficult. It is the purpose of this note to point out that several of the measures of PO in common use are equivalent and simple relationships exist between them.

Franzgrote, E.**F06 INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS**

Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A., Patterson, J. H., Franzgrote, E.

Technical Report 32-1065 (Unclassified)

(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 12, December 1966, pp. 1681-1686)

For abstract, see Turkevich, A.

F07 CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION

Turkevich, A. L., Knolle, K., Franzgrote, E., Patterson, J. H.

Technical Report 32-1090 (Unclassified)

(Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 2, January 15, 1967, pp. 831-839)

For abstract, see Turkevich, A. L.

Freeman, R. F.**F08 POLYMERIC APPLICATIONS FOR THE MARINER MARS, 1964 SPACECRAFT**

Freeman, R. F., Boundy, R. A., Harrington, R.

Technical Report 32-1031 (Unclassified)

(Reprinted from *Rubber and Plastic Age*, July 1966)

Principal applications of polymeric materials in various subsystems of the *Mariner* Mars 1964 spacecraft included lubrication, thermal control, and structural uses. In the selection of these materials, many factors normally absent from terrestrial applications had to be considered. In addition to evaluating data from prior space flights and research, two basic tests were performed to determine the best qualified materials: a weight-loss test, to indicate the degree of material degradation in a thermal-vacuum environment; and a volatile-condensable-material test, to indicate the probable extent to which outgassing materials would condense on critical spacecraft components. The successful *Mariner IV* mission confirmed the proper selection of materials.

Garba, J. A.**G01 A COMPARISON OF SOME PREDICTED AND MEASURED VARIABLES FOR A FULL-SCALE SURVEYOR DROP TEST**

Garba, J. A.

Technical Report 32-1084, March 1, 1967

(Unclassified)

This Report describes the correlation between the predicted and measured dynamic behavior for a full-size *Surveyor* drop test. The investigation includes a detailed examination of the test uncertainties encountered in a full-scale stability drop of a three-legged vehicle and the effect of such uncertainties on the correlation between experimental and theoretical results. Time histories of the pertinent variables are presented and discussed.

Gardner, F. M.

G02 DIGITAL TO ANALOG PULSER SYSTEM FOR TESTING PULSE HEIGHT ANALYZERS

Gardner, F. M., McKeethen, R.
Technical Report 32-1049 (Unclassified)
(Reprinted from *Nuclear Instruments and Methods*, Vol. 46,
North-Holland Publishing Co., 1967, pp. 121-124)

A method is presented for both integral and differential linearity testing of pulse height analyzers. A novel technique is discussed that employs a digital to analog converter approach to simplify the testing. The construction and performance of 9 pulse height analyzers are described, and results of testing two units are presented.

Gary, B.

G03 RESULTS OF A RADIOMETRIC MOON-MAPPING INVESTIGATION AT 3 MILLIMETERS WAVELENGTH

Gary, B.
Technical Report 32-1058 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 1,
January 1967, pp. 245-254)

This is the second of two papers describing an attempt to determine the nature of the lunar surface material from an analysis of the monthly variation of the Moon's 3.3-mm wavelength thermal emission. A 15-ft-diameter radio telescope was used to construct high angular resolution radiometric maps consisting of brightness temperature contours on the Moon's disk for 14 representative lunar phases. An analysis was performed on the thermal behavior of five maria and portions of a large highland region. The final results of this analysis are presented in this Report.

The observed temperature variation during a lunation has been compared with predictions based on a model for the lunar surface which allows for the existence of vertical and horizontal inhomogeneities of certain parameters of the lunar material. Values for these parameters have been subjected to constraints imposed by infrared observations of the lunar nighttime surface temperature. No combination of parameter values permitted by these constraints can account for the microwave observations. Suggestions are given for possible improvements of the lunar model.

Gensel, D. R.

G04 DESERT SOIL COLLECTION AT THE JPL SOIL SCIENCE LABORATORY

Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report 32-977, October 15, 1966
(Unclassified)

For abstract, see Cameron, R. E.

Gerbracht, F. G.

G05 AN EXPERIMENTAL CORRELATION OF THE NONREACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE PART II. INSTRUMENTATION, EXPERIMENTAL APPARATUS, AND EXPERIMENTAL TECHNIQUES

Clayton, R. M., Rupe, J. H., Gerbracht, F. G.
Technical Report 32-255, May 15, 1967 (Unclassified)

For abstract, see Clayton, R. M.

Giffin, C. E.

G06 MISSION TO A COMET: PRELIMINARY SCIENTIFIC OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Giffin, C. E.,
Neugebauer, M. M., Smith, E. J., Willingham, D. E.
Technical Memorandum 33-297, February 15, 1967
(Unclassified)

For abstract, see Brereton, R. G.

Gin, W.

G07 REVIEW OF SELECTED PROBLEMS IN THE UTILIZATION OF SOLID PROPELLANT ROCKET MOTORS IN SPACE

Gin, W.
Technical Memorandum 33-292, August 15, 1966
(Unclassified)

This Technical Memorandum reviews the selected design, development, and operational problems and solutions associated with the use of solid propellant rocket motors for space propulsion. Preliminary results from work on motors for heat-sterilized spacecraft (to prevent the contamination of certain planets) indicate unique problems. Thermal control in space of a lunar retro-rocket is provided by superinsulation with precautions taken to preclude the accumulation of static charge. Hard vacuum effects on solid propellants appear not to constitute a performance problem, but ignitability must be evaluated because of surface loss of additives. Meteoroid hazard remains difficult to assess, but thermal control surfaces probably will serve to protect against meteoroid impact. Impingement by gases and solids from the motor exhaust on nearby spacecraft components may result in a transfer of heat and momentum, or it may coat optically sensitive surfaces; the determination of solid particle size in the exhaust is presently in a controversial state. Thrust-vector misalignment from unsymmetrically eroding nozzle throats or spalling divergent cones has been studied by cold flow. Performance required by the mission and achievable by the solid rocket is reviewed with attention to acceleration, specific impulse, density, and mass ratio requirements. Launch vehicle capability has a first-order effect on requirements. Cost and reliability are discussed in terms of possible improvement in cost effectiveness.

Giver, L. P.

G08 HIGH-DISPERSION SPECTROSCOPIC OBSERVATION OF MARS

I. THE CO₂ CONTENT AND SURFACE PRESSURE

Spinrad, H., Schorn, R. A., Moore, R., Giver, L. P., Smith, H. J.

Technical Report 32-1048 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 146, No. 2, November 1966, pp. 331-338)

For abstract, see Spinrad, H.

G09 HIGH-DISPERSION SPECTROSCOPIC OBSERVATIONS OF MARS

II. THE WATER-VAPOR VARIATIONS

Schorn, R. A., Spinrad, H., Moore, R. C., Smith, H. J., Giver, L. P.

Technical Report 32-1048 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 2, February 1967, pp. 743-752)

For abstract, see Schorn, R. A.

Goforth, L.

G10 VENUS/MERCURY SWINGBY WITH VENUS CAPSULE: PRELIMINARY SCIENCE OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S.

Barath, F. T., Herriman, A. G., Goforth, L.

Technical Memorandum 33-332, May 1, 1967 (Unclassified)

For abstract, see Brereton, R. G.

Goldstein, R. M., et al.

G11 THE SUPERIOR CONJUNCTION OF MARINER IV

Goldstein, R. M., et al.

Technical Report 32-1092, April 1, 1967

(Unclassified)

The path of the *Mariner IV* spacecraft passed within 0.9 deg of the center of the sun just after superior conjunction. Experiments were conducted in order to probe the solar corona with an S-band radio signal. One- and two-way modes of signal transmission were used. Spectrograms were obtained, and spectral broadening was the primary observable result of passing a monochromatic signal through the solar corona.

Gray, L. D.

G12 TRANSMISSION OF THE ATMOSPHERE OF MARS IN THE REGION OF 2 μ

Gray, L. D.

Technical Report 32-969 (Unclassified)

(Reprinted from *Icarus: International Journal of the Solar System*, Vol. 5, No. 4, July 1966, pp. 390-398)

The random Elasser band model is used to compute the transmission of the atmosphere of Earth and Mars for the 2- μ bands of carbon dioxide. This band model is shown to give good agreement with measurements of spectral transmission for homogeneous paths of carbon dioxide and also for non-homogeneous paths through the Earth's atmosphere when the Curtis-Godson approximation is used. The 2- μ bands of carbon dioxide are strong in the atmospheres of both Earth and Mars, and, at a given temperature, their absorption is a function only of the product mp . Comparison of calculated values for transmission of sunlight through both atmospheres indicates that $(mp)_\delta = 500 \pm 100$ m-atm-mbar, where m is the amount of carbon dioxide in one air mass and p is the "effective" surface pressure. For $m_\delta = 60$ to 85 m-atm, the above value of $(mp)_\delta$ leads to a surface pressure of the Martian atmosphere, $p_s_\delta = 7.1 \pm 2.2$ mbar.

Grelecki, C.

G13 SURVEYOR VERNIER ENGINE FUEL BLEND-A CONSTRAINED OPTIMIZATION

Wrobel, J. R., Grelecki, C.

Technical Report 32-1102 (Unclassified)

(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 4, No. 3, March 1967, pp. 347-353)

For abstract, see Wrobel, J. R.

Griffin, D. C.

G14 LITHIUM-BOILING POTASSIUM TEST LOOP INTERIM REPORT

Kikin, G. M., Davis, J. P., Griffin, D. C., Peelgren, M. L., Phillips, W. M.

Technical Report 32-1083, September 15, 1966 (Unclassified)

For abstract, see Kikin, G. M.

Gronroos, H.

G15 REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS

VOLUME II. REACTOR PHYSICS SUMMARY

Gronroos, H.

Technical Memorandum 33-262, October 15, 1965 (Confidential)

This Memorandum, which is part of a three-part survey of industry-proposed in-pile thermionic reactor concepts and potential nuclear fuels for space application, presents a summary of reactor physics considerations in thermionic reactor design. Only in-pile thermionic concepts for space-powerplant application are investigated, comparing the flashlight, pancake, and externally fueled designs. The main problem areas are outlined together with suggested analytical and experimental investigations.

Haack, R. F.

- H01 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.**
I. ELECTRON TRANSFER FROM SODIUM TO POLY-4-VINYLBIPHENYL AND POLYVINYLNAPHTHALENES
Rembaum, A., Moacanin, J., Haack, R. F.
Technical Report 32-1054, Part I (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 4, October 1966, pp. 657-672)

For abstract, see Rembaum, A.

- H02 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.**
II. ELECTRON TRANSFER FROM SODIUM TO POLYACENAPHTHYLENE
Rembaum, A., Haack, R. F., Hermann, A. M.
Technical Report 32-1054, Part II (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 4, October 1966, pp. 673-691)

For abstract, see Rembaum, A.

Haines, E. L.

- H03 PULSE HEIGHT DEFECT AND ENERGY DISPERSION IN SEMICONDUCTOR DETECTORS**
Haines, E. L., Whitehead, A. B.
Technical Report 32-891 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 2, February 1966, pp. 190-194)

This Report presents a calculation of the contributions of the atomic (screened Coulombic) scattering process to the pulse height defect and energy dispersion observed when heavy ions expend their energies in semiconductor detectors. Atomic scattering appears to account qualitatively for the pulse height defect observed for most heavy ions in both silicon and germanium detectors. Atomic scattering also contributes substantially to the energy dispersion.

Hama, F. R.

- H04 EXPERIMENTAL INVESTIGATIONS OF WEDGE BASE PRESSURE AND LIP SHOCK**
Hama, F. R.
Technical Report 32-1033, December 1, 1966
(Unclassified)

Base- and surface-pressure measurements and schlieren and shadowgraph observations were conducted on 6-deg half-angle wedges of various separation-edge shapes. The lip shock emanating from even a sharp separation edge was found to be of substantial strength, contrary to the prevailing belief. In most

of the cases investigated, the predominant cause of the lip shock appeared to be the viscous separation effect similar to that of the separation shock emanating from a circular cylinder, rather than the inviscid rotational effect.

Hand, P. J.

- H05 RANGER BLOCK III ATTITUDE CONTROL SYSTEM MANUFACTURING, TESTING AND PERFORMANCE**
Almaguer, T. A., Jr., Baxter, T. G., Hand, P. J., Perkins, G. S., Summers, R. H.
Technical Report 32-915, September 15, 1966
(Unclassified)

For abstract, see Almaguer, T. A., Jr.

Hanson, R. J.

- H06 ANALYTIC LINEAR SYSTEMS OF DIFFERENTIAL EQUATIONS IN IMPLICIT FORM**
Hanson, R. J.
Technical Report 32-1041, December 1, 1966
(Unclassified)

A local theory is developed for the system $B(z)(dy/dz) = A(z)y + f(z)$ for square holomorphic matrices A and B and a holomorphic vector f with the assumption that $\det B(z) \equiv 0$. Necessary and sufficient conditions for the existence of a solution to the system and an algorithm for calculating this solution (provided it exists) are given.

Harding, J. T.

- H07 FINAL REPORT: THE CRYOGENIC GYROSCOPE PROGRAM AT JET PROPULSION LABORATORY**
Harding, J. T.
Technical Report 32-897, July 1, 1966
(Unclassified)

This Report is a technical account of the JPL development program for the superconducting gyroscope conducted from June 1958 to September 1965. The program, which began with levitating a superconducting ball with a single coil, advanced to the point where total drift as low as 1 deg/day was obtained with a research model of the gyro. The principal problems encountered in the program (namely: rotor fabrication, alternating magnetic-field losses in superconductors, magnetic-field configuration required for levitation, damping of rotor oscillation, refrigeration, spinup, and readout) are discussed. However, because a multitude of reports has been issued during the course of this program, the text is concise; for details, the reader is referred to previously issued reports, which are compiled under separate cover in the *Appendix to the Final Report*.

H08 METHOD FOR RAPIDLY REVERSING MAGNETIC FIELD IN SHORTED SUPERCONDUCTING COIL
Harding, J. T.

Technical Report 32-1030 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*,
Vol. 37, No. 10, October 1966, pp. 1350, 1351)

A shorted superconducting coil carrying a persistent current can be made to reverse its field in less than 5 msec by subjecting the coil to an increasing external reverse field. The superconducting coil opposes a change in its interior field until its critical current is exceeded, whereupon rapid extinction of the persistent current occurs, thus admitting the external field. Details of this procedure are discussed in this Report.

Harrington, R.

H09 POLYMERIC APPLICATIONS FOR THE MARINER MARS, 1964 SPACECRAFT

Freeman, R. F., Boundy, R. A., Harrington, R.
Technical Report 32-1031 (Unclassified)
(Reprinted from *Rubber and Plastic Age*, July 1966)

For abstract, see Freeman, R. F.

Hayes, C. D.

H10 POWER SPECTRAL DENSITY ANALYSIS

Hayes, C. D.
Technical Report 32-928, Revision 1, March 15, 1967
(Unclassified)

Generalized techniques are developed for determining the equation describing the power spectral density function (G^2/cps versus frequency, etc.) and the equation for determining the root mean square of a power spectral density function. Examples of both types of equations are included in this Report.

H11 OCTAVE AND ONE-THIRD OCTAVE ACOUSTIC NOISE SPECTRUM ANALYSIS

Hayes, C. D., Lamers, M. D.
Technical Report 32-1052, January 15, 1967
(Unclassified)

This Report is a compilation of derivations for analyzing acoustic noise spectra. These derivations consist of mathematical techniques for: (1) combining the decibel levels of either octaves or constant bandwidths into an over-all spectrum level, (2) determining the octave levels in a second octave system when the levels in the first octave are known, and (3) determining one-third octave levels when the octave levels and the decibel-per-octave slope are known. The appendixes contain tables of new and old A.S.A. (American Standards Association) recommended octave designations; decibel equivalents for power, voltage, and pressure; and conversion for some useful acoustic constants. These mathematical techniques and tables provide useful information for the engineer or scientist working in the field of acoustics.

Hays, L. G.

H12 COMPARISON OF LIQUID-METAL MAGNETOHYDRODYNAMIC POWER CONVERSION CYCLES

Weinberg, E., Hays, L. G.
Technical Report 32-946, July 1, 1966
(Unclassified)

For abstract, see Weinberg, E.

H13 SUMMARY OF TURBINE EROSION MEETING
(Held at JPL, December 29-30, 1966)

Hays, L. G.
Technical Memorandum 33-354, June 15, 1966
(Unclassified)

This Memorandum presents a summary of the proceedings of an informal meeting which was held to review two turbine-erosion research programs that are directed for the Office of Advanced Research and Technology, NASA, by the Jet Propulsion Laboratory. Abstracts of the talks, copies of visual material, and notes that emphasize important issues or questions raised during the discussions are included.

Hermann, A. M.

H14 HALL EFFECT IN POLY-*n*-VINYLCARBAZOLE- IODINE CHARGE-TRANSFER COMPLEX

Hermann, A. M., Rembaum, A.
Technical Report 32-995 (Unclassified)
(Reprinted from *Journal of Applied Physics*, Vol. 37, No. 9, August 1966, pp. 3642-3643)

The mechanism of electronic conduction in monomeric or polymeric charge-transfer complexes is, at present, not well understood. Many complexes have high impedances that have heretofore prohibited measurement of fundamental characteristics such as the Hall mobility. The development of an AC technique for the measurement of the Hall effect in materials of high resistivity and low mobility has permitted the measurement of the Hall mobility in compressed pellets of poly-*n*-vinylcarbazole complexed with iodine (impedance $\sim 1M\Omega$). This Report presents room-temperature mobilities in this complex and also points out the discrepancy in sign of the majority carriers, i.e., a negative Hall coefficient and a positive Seebeck coefficient. The December voltage supports *n*-type conduction as found in the Hall effect. It is believed that the Hall mobilities presented are the first to be reported for a charge-transfer complex.

H15 HALL EFFECT AND TRANSPORT PROPERTIES OF IODINE

Hermann, A. M.
Technical Report 32-1005 (Unclassified)
(Reprinted from the *Journal of Physics and Chemistry of Solids*, Vol. 27, September 1966, pp. 1551-1552)

The Hall effect has been measured in single crystals of iodine by an AC technique. The apparatus has been described

in detail in a previous paper. The electric field was applied to the sample at 13½ cps, the sample was rotated in a static magnetic field at 20 cps, and the Hall signal was preamplified by field-effect transistors mounted on the rotation shaft near the sample and was synchronously detected at 33½ cps.

H16 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.

II. ELECTRON TRANSFER FROM SODIUM TO POLYACENAPHTHYLENE

Rembaum, A., Haack, R. F., Hermann, A. M.
Technical Report 32-1054, Part II (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*,
Vol. I, No. 4, October 1966, pp. 673-691)

For abstract, see Rembaum, A.

Herrera, J. G.

H17 INITIAL PERFORMANCE OF A NEW NOZZLE GAS-DYNAMICS TEST FACILITY

Strand, L. D., Newton, J. F., Jr., Herrera, J. G.
Technical Memorandum 33-310, November 15, 1966
(Unclassified)

For abstract, see Strand, L. D.

Herriman, A. G.

H18 VENUS/MERCURY SWINGBY WITH VENUS CAPSULE: PRELIMINARY SCIENCE OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S.
Barath, F. T., Herriman, A. G., Goforth, L.
Technical Memorandum 33-332, May 1, 1967 (Unclassified)

For abstract, see Brereton, R. G.

Higa, W. H.

H19 LOW-LEVEL MICROWAVE MIXING IN RUBY

Higa, W. H.
Technical Report 32-1016 (Unclassified)
(Reprinted from the *Proceedings of the IEEE*,
Vol. 54, No. 10, October 1966, p. 1453)

A demonstration of microwave mixing in a paramagnetic crystal made using a traveling-wave maser (TWM) is the subject of this Report. No internal modifications were made to the TWM, and a small segment of ruby at the input end of the TWM served as the mixer element. It is shown that the results obtained at X-band were also obtained at K-band. The four energy levels in ruby allowed the K-band experiment to be performed simply by changing the pumping frequency. The ruby was operated in the 90-deg orientation at a magnetic field of about 2400 gauss.

Hollywood, L. P.

H20 STORAGE TESTS OF NITROGEN TETROXIDE AND HYDRAZINE IN ALUMINUM CONTAINERS

Hollywood, L. P., Metz, T. R., Porter, R. N.
Technical Report 32-1039, January 15, 1967
(Unclassified)

Short-term compatibility tests were conducted using small canisters of Types 2014 and 6061 aluminum alloy filled with nitrogen tetroxide and hydrazine to determine the effect of different cleaning procedures. Only minor differences were noted. A flight-weight propellant tank of Type 2014 aluminum alloy used to store hydrazine was only slightly corroded after 46-mo storage. Firing tests showed the stored fuel delivered slightly less performance; however, it ignited and burned as smoothly as stock hydrazine with nitrogen tetroxide.

Horowitz, N. H.

H21 THE SEARCH FOR EXTRATERRESTRIAL LIFE

Horowitz, N. H.
Technical Report 32-921 (Unclassified)
(Reprinted from *Science*, Vol. 151, No. 3712,
February 18, 1966, pp. 789-792)

Present knowledge does not permit the conclusion that, if life ever existed on Mars, it is now extinct. In this article, a discussion of the coming search for life on Mars has been attempted. Venus, our neighbor among the planets, has been excluded from consideration because its high surface temperature seems incompatible with life. The planets of the solar system beyond Mars are out of reach for the present.

H22 THE BIOLOGICAL SIGNIFICANCE OF THE SEARCH FOR EXTRATERRESTRIAL LIFE

Horowitz, N. H.
Technical Report 32-1000, August 15, 1966
(Unclassified)

This Report proposes to show that there is a chemical mark or a whole series of marks that is stamped on all terrestrial life forms which are known to us, and also to show how this is related to our basic comprehension of the living state.

It will be argued that the discovery of any significant change in this chemical identification mark would constitute sufficient evidence for the separate origin of an extraterrestrial life form.

H23 GROWTH OF AEROBIC AND ANAEROBIC BACTERIA IN AGAR SUBJECTED TO FREEZING AND DIURNAL FREEZING AND THAWING

Cameron, R. E., Blank, G. B., Horowitz, N. H.
Technical Memorandum 33-331, June 15, 1967
(Unclassified)

For abstract, see Cameron, R. E.

Jacobs, I. M.

J01 PROBABILITY-OF-ERROR BOUNDS, FOR BINARY TRANSMISSION ON THE SLOWLY FADING RICIAN CHANNEL

Jacobs, I. M.

Technical Report 32-1051 (Unclassified)

(Reprinted from *IEEE Transactions on Information Theory*, Vol. IT-12, No. 4, October 1966, pp. 431-441)

Chernoff bounds and tilted distribution arguments are applied to obtain error probability bounds for binary signaling on the slowly-fading Rician channel with L diversity. For the maximum likelihood receiver, the CB-optimum [optimum in the sense of minimizing the Chernoff (upper) bound on error probability] signal correlation is determined and plotted; it is found that antipodal signals should be used if $a > b^2(1+b)$, where a is the signal-to-noise ratio of the specular components and b is that of the fading components. The CB-optimum number of diversity paths is then obtained. If $a/b > 0.2$, antipodal signaling with unlimited diversity is CB-optimum; whereas, if $a/b < 0.2$, orthogonal signaling with properly chosen diversity is very nearly CB-optimum. If restricted to orthogonal signaling, unlimited diversity is CB-optimum whenever $a/b > 1.0$. Similar results are obtained for the generally nonoptimum square-law-combining receiver. In this case, orthogonal signaling with finite diversity is always CB-optimum.

Jaffe, L. D., et al.

J02 SURVEYOR I: PRELIMINARY RESULTS

Jaffe, L. D., et al.

Technical Report 32-1001 (Unclassified)

(Reprinted from *Science*, Vol. 152, No. 3730, June 24, 1966, pp. 1737-1750)

This Report is an analysis and an evaluation of data returned during the *Surveyor* spacecraft's first 5 days on the Moon. The Report was prepared by the *Surveyor* Scientific Evaluation and Analysis Team and associated working groups.

J03 LUNAR SURFACE STRENGTH: IMPLICATIONS OF LUNA 9 LANDING

Jaffe, L. D., Scott, R. F.

Technical Report 32-1003 (Unclassified)

(Reprinted from *Science*, Vol. 153, No. 3734, July 22, 1966, pp. 407-408)

The ability of the lunar surface to support statically the *Luna 9* capsule indicates that the surface can bear at least 5×10^3 dyne per square centimeter (10^{-1} lb/in.²). Analysis of the landing dynamics, using available data, gives a lower bound of about 1 to 2×10^5 dyne/cm², but this estimate may not be conservative because of uncertainties regarding the shock absorbing system used and the direction of the velocity vector at impact.

J04 LUNAR OVERLAY DEPTH IN MARE TRANQUILLITATIS, ALPHONSUS, AND NEARBY HIGHLANDS

Jaffe, L. D.

Technical Report 32-1021 (Unclassified)

(Reprinted from *Icarus: International Journal of the Solar System*, Vol. 5, No. 5, September 1966, pp. 545-550)

Photographs of lunar craters obtained by the *Ranger VIII* and *Ranger IX* spacecraft have been compared with those of laboratory craters overlain with known amounts of granular material. Results are consistent with the interpretation that at least 5 m of granular material, and probably considerably more, have been deposited on Mare Tranquillitatis, Alphonsus, and nearby highland areas, subsequent to the formation of most of the craters 55 m in diameter or larger. This applies to both impact craters and those apparently of volcanic origin. The appearance of craters smaller than 30 m in diameter is consistent with less deposit of overlay subsequent to crater formation; hence, these craters are believed to be newer.

**J05 SURVEYOR I MISSION REPORT
PART III. TELEVISION DATA**

Jaffe, L. D.

Technical Report 32-1023, October 11, 1966

(Unclassified)

Some 281 selected television photographs of the lunar surface acquired and transmitted by the *Surveyor I* spacecraft between June 2 and July 14, 1966, are presented in this Report. The accompanying information provides assistance in the interpretation of these pictures. The supporting material is comprised of descriptions of the television subsystem, the orientation of the camera and the Sun, and the ground photo-recording system, as well as camera parameter information. In addition, 32 preliminary mosaics aid with spatial relationship interpretation.

J06 LUNAR SURFACE STRENGTH

Jaffe, L. D.

Technical Report 32-1068 (Unclassified)

(Reprinted from *Icarus: International Journal of the Solar System*, Vol. 6, No. 1, January 1967, pp. 75-91)

Lower bounds for the strength of the lunar surface are derived from the properties necessary to provide stability of the slopes observed in *Ranger VII*, *VIII*, and *IX* imagery. Additional information was obtained from *Luna 9* data, from hydrostatic considerations, and from laboratory tests. Utilized in some of the calculations were density data derived from radar and thermal emission measurements. A model of the surface layer is outlined.

James, J. N.

J07 THE VOYAGE OF MARINER IV

James, J. N.

Technical Report 32-958 (Unclassified)

(Reprinted from *Scientific American*, Vol. 214, No. 3, March 1966, pp. 42-52)

The voyage of *Mariner IV* in which numerous obstacles were overcome to put a 575-pound spacecraft within 6,118 miles of Mars after a trip of 228 days, was a tremendous scientific effort. This is the first of a three-part series on the mission and its results.

Jet Propulsion Laboratory

J08 RANGER VI MISSION DESCRIPTION AND PERFORMANCE

Jet Propulsion Laboratory

Technical Report 32-699, December 15, 1966

(Unclassified)

On January 30, 1964, the *Ranger VI* spacecraft was launched on a lunar impact trajectory to obtain close-up television pictures of the lunar surface. A failure in the television subsystem prevented the achievement of this objective. However, the flight successfully demonstrated a full operational capability and provided an impact on the lunar surface on February 2, 1964, at 9.3-deg north selenographic latitude and 21.5-deg east longitude, within 20 mi of the aiming point.

J09 MARINER MARS 1964 PROJECT REPORT: MISSION AND SPACECRAFT DEVELOPMENT VOLUME II: APPENDIXES

Jet Propulsion Laboratory

Technical Report 32-740, March 1, 1965

(Unclassified)

This volume of the *Mariner Mars 1964* Project Report contains the basic working documents that were used during the project for monitoring and controlling the progress of spacecraft development. No attempt has been made to recast these documents into a formal style or format; they appear here in essentially the same form as that in which they were used during the project.

It is hoped that the material included here will provide a fairly comprehensive picture of the management devices used in the development of a successful interplanetary spacecraft. Many of these documents may be of use as reference material to those working on other interplanetary missions. A brief explanation is included with each appendix, and a more complete discussion is found in Volume I of TR 32-740.

J10 MARINER MARS 1964 PROJECT REPORT: MISSION OPERATIONS

Jet Propulsion Laboratory

Technical Report 32-881, June 15, 1966

(Unclassified)

On November 28, 1964, *Mariner IV* was successfully launched on a trajectory that would take it within 150,000 miles of Mars. On December 5, 1964, the spacecraft performed a successful midcourse maneuver, altering its flight path so that it would pass within 6,118 miles of the planet. The flight took approximately 7½ months, during which time a great deal of scientific information was gathered concerning

the environment of both near-Earth and interplanetary space. And then, on July 14, 1965, *Mariner IV* photographed the surface of Mars, and telemetered to Earth the most advanced scientific and technical data regarding the planet yet recorded.

An earlier volume of the series reports on *Mariner III*. This volume, which deals with *Mariner IV* only, describes various operations of the Project during the flight from the time of mid-course maneuver to the end of the mission on October 1, 1965. It includes an account of the trajectory and orbit determination analyses, a description of the Space Flight Operations System, a summary of the post-launch testing results, and a brief account of the final configuration and disposition of the MC-4 and PTM spacecraft at the end of the mission.

J11 MARINER MARS 1964 PROJECT REPORT: SPACECRAFT PERFORMANCE AND ANALYSIS

Jet Propulsion Laboratory

Technical Report 32-882, February 15, 1967

(Unclassified)

The *Mariner Mars 1964* Project required the use of many new techniques in designing, building, and operating unmanned spacecraft. The success of the *Mariner IV* mission made these techniques significant, particularly in the light of future space programs. This volume of the *Mariner Mars 1964* Project Report describes the system- and subsystem-level performance of the *Mariner IV* spacecraft from its November 28, 1964 launch through the end of the first mission phase on October 1, 1965. Operations planning and problem investigations performed in support of the *Mariner IV* mission are discussed.

J12 SURVEYOR I MISSION REPORT PART I. MISSION DESCRIPTION AND PERFORMANCE

Jet Propulsion Laboratory

Technical Report 32-1023, August 31, 1966

(Unclassified)

Surveyor I, the first of a series of unmanned, soft-landing missions, was launched from Cape Kennedy, Florida, on May 30, 1966, and achieved a perfect soft-landing on the moon, June 2, 1966. All project and flight objectives for this mission were satisfied. The spacecraft (*Surveyor I*) continued to operate successfully and provide telemetry data until two days after sunset of the first lunar day, when telemetry transmission was purposely discontinued for the lunar night. Spacecraft operation was resumed during the second lunar day and continued performing until sunset, July 14, 1966, when the operational phase of the *Surveyor I* mission was terminated. Over 100,000 ground commands were transmitted to the spacecraft during the course of the mission, and over 11,000 pictures were returned and recorded. A large quantity of data was also received related to lunar bearing strength, radar reflectivity, and surface temperature of the moon. A technical description of the mission and an evaluation of the engineering results are presented here.

J13 SURVEYOR I MISSION REPORT
PART II. SCIENTIFIC DATA AND RESULTS
Jet Propulsion Laboratory
Technical Report 32-1023, September 10, 1966
(Unclassified)

This three-part document constitutes the Project Mission Report on *Surveyor I*, the first in a series of unmanned lunar soft-landing missions.

Part II presents the scientific data derived from the mission, and the scientific analysis conducted by the members of the *Surveyor* scientific evaluation and analysis team and the five associated working groups.

The results given in this Report are based upon data evaluation prior to September 10, 1966. It is expected that future evaluation and analysis of the *Surveyor I* data will provide additional scientific results.

J14 SURVEYOR II MISSION REPORT: MISSION DESCRIPTION AND PERFORMANCE
Jet Propulsion Laboratory
Technical Report 32-1086, April 1, 1967 (Unclassified)

Surveyor II, the second of a series of unmanned missions designed to soft-land on the moon, was launched from Cape Kennedy, Florida, on September 20, 1966. After a nominal launch phase and accurate injection into lunar transfer trajectory, a normal transit phase was achieved until execution of midcourse velocity correction, when one of the three vernier engines failed to fire. The spacecraft tumbling condition that resulted could not be corrected, causing premature termination of the mission. A thorough investigation by a Failure Review Board has not disclosed a specific cause for the failure. A technical description of the mission and an evaluation of engineering data obtained are presented in this Report.

Johnson, A. C.

J15 A NUMERICAL FILTER PROGRAM
Johnson, A. C.
Technical Memorandum 33-344, July 1, 1957
(Unclassified)

A straightforward and general numerical filter program was designed and written in FORTRAN IV language for the IBM 7094 and the SDS 930 computers. The filter (smoothing) techniques presented in this Memorandum are valid for sequences of equidistant data. This program may be used for signal detection and extraction and general data smoothing. Inputs to the program consist of the data sequence and five control parameters. Outputs include listings of the input and output data values and two plots of the input signal and of the output signal. A sketch of the analytical background and a discussion of parameters which are critical for this numerical filter program are also presented.

Juvinall, G. L.

J16 NUCLEAR MAGNETIC RESONANCE OF PHOSPHORUS COMPOUNDS.
II. THE RELATIVE SIGNS OF THE SPIN-SPIN COUPLINGS IN DIMETHYLPHOSPHINE AND METHYLPHOSPHINE
Manatt, S. L., Juvinall, G. L., Wagner, R. I., Elleman, D. D.
Technical Report 32-974 (Unclassified)
(Reprinted from *Journal of the American Chemical Society*, Vol. 88, No. 12, June 20, 1966, pp. 2689-2697)

For abstract, see Manatt, S. L.

Kalfayan, S. H.

K01 EFFECTS OF THE THERMAL STERILIZATION PROCEDURE ON POLYMERIC PRODUCTS
Kalfayan, S. H., Campbell, B. A.
Technical Report 32-973, November 15, 1966
(Unclassified)

The effects of thermal sterilization on approximately 160 polymeric products used on the *Ranger* and *Mariner* spacecrafts were investigated. After classification according to function, the products were first subjected to a preliminary screening program, consisting of a 36-hr exposure at 145°C in dry nitrogen with a limited amount of testing, to screen out products of low thermal stability. Those that met the preliminary thermal compatibility criteria were subjected to the more severe JPL type-approval procedure, i.e.: 3 cycles of 36-hr exposure at 145°C in dry nitrogen. More extensive testing was conducted in this phase of the program both before and after thermal exposure to determine changes in the physical, mechanical, electrical, and thermal properties of the products. This Report presents the results of the investigation, including a discussion of the criteria used to evaluate the products and the specific compatibility ratings assigned to each product as a result of the tests.

Kaplan, L. D.

K02 MARS: NEW ABSORPTION BANDS IN THE SPECTRUM
Connes, J., Connes, P., Kaplan, L. D.
Technical Report 32-996 (Unclassified)
(Reprinted from *Science*, Vol. 153, No. 3737, August 1966, pp. 739-740)

For abstract, see Connes, J.

K03 TRACES OF HCl AND HF IN THE ATMOSPHERE OF VENUS
Connes, P., Connes, J., Benedict, W. S., Kaplan, L. D.
Technical Report 32-1106 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 3, March 1967, pp. 1230-1237)

For abstract, see Connes, P.

Keeler, L. H.

**K04 A SENSITIVE S-BAND NOISE RECEIVER
DEVELOPED FOR THE MARINER MARS 1964
SPACECRAFT PROGRAM**

Keeler, L. H., Nalbandian, A. J., Olbeter, A. A.
Technical Report 32-1029, November 15, 1966
(Unclassified)

A sensitive S-band noise receiver was required for the *Mariner Mars 1964* Project to verify spacecraft subsystems' compatibility with the telecommunications subsystem. The basic problem was to design a readily portable, high-resolution, low-noise receiver system having a sensitivity approaching that of the permissible noise level for the *Mariner Mars 1964* spacecraft and a broad tuning range. A receiver utilizing a parametric amplifier and modified spacecraft transponder designs and modules was developed. Predetection recording was incorporated along with a manual scan subsystem. It was determined that the noise receiver system permitted measurements as low as -151 dbm in a 100-Hz bandwidth. The receiver system and stable calibration source designs are discussed in this Report.

The noise receiver tests during spacecraft testing at JPL and the Eastern Test Range (ETR) are summarized. The noise receiver system performed reliably and accurately, and no major compatibility problems were encountered. The system verified that undesirable noise levels or spectral components were not present in the critical frequency regions, and standby support for crucial tests during JPL and ETR spacecraft operations was provided. Some system design improvements for future spacecraft operational support requirements are discussed. The receiver system noise-figure measurements, the operational procedure employed, and the system noise temperature analysis for space chamber tests and high bay tests (JPL) are described.

Kikin, G. M.

**K05 LITHIUM-BOILING POTASSIUM TEST LOOP
INTERIM REPORT**

Kikin, G. M., Davis, J. P., Griffin, D. C., Peelgren, M. L.,
Phillips, W. M.
Technical Report 32-1083, September 15, 1966
(Unclassified)

This Report covers the construction, instrumentation and initial phase of operation of the lithium-boiling potassium test loop at JPL. The primary purpose of this facility is to investigate overall transient and steady-state characteristics, startup, control, and stability of a two-loop, alkali-metal, Rankine cycle system of the type contemplated for ultimate application to spacecraft nuclear-electric propulsion. The initial phase of operation provides valuable experience in liquid-metal system startup and shutdown, high-temperature instrumentation, control, boiling stability, and general operational characteristics. Further loop operations will be concerned with the specific transient test program for determination of various thermal-hydraulic characteristics.

Kirhofer, W. E.

K06 RANGER VII PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.
Technical Report 32-964, November 1, 1966
(Unclassified)

Photographic parameters necessary for detailed interpretation of the *Ranger VII* pictures are listed for all of the Camera A and B photographs and for selected Camera P photographs. Parameter accuracies and the method of data generation are discussed.

K07 RANGER VIII PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.
Technical Report 32-965, November 1, 1966
(Unclassified)

Photographic parameters necessary for detailed interpretation of the *Ranger VIII* pictures are listed for selected photographs, including all those published in the *Ranger VIII* atlases. Parameter accuracies and the method of data generation are discussed.

K08 RANGER IV PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.
Technical Report 32-966, September 15, 1966
(Unclassified)

Photographic parameters necessary for detailed interpretation of the *Ranger IX* pictures are listed for selected photographs, including all photographs published in the *Ranger IX* atlases. Parameter accuracies and the method of data generation are discussed.

Kirsten, C.

K09 SURVEYOR SPACECRAFT TELECOMMUNICATIONS

Kirsten, C.
Technical Report 32-1105, March 15, 1967 (Unclassified)

This Report describes the *Surveyor* on-board telecommunications system, giving actual subsystem implementation and performance. The antennas, transmitters, receivers, the command subsystem, and signal processing are discussed. Re-design requirements are presented.

Kistler, A. L.

**K10 GRID TURBULENCE AT LARGE REYNOLDS
NUMBERS**

Kistler, A. L., Vrebalovich, T.
Technical Report 32-985 (Unclassified)
(Reprinted from *Journal of Fluid Mechanics*, Vol. 26,
Part 1, 1966, pp. 37-47)

Measurements of grid turbulence have been obtained for grid Reynolds numbers ranging from 2.4×10^6 to 1.2×10^5 . The decay law and the effect of Reynolds number on the turbulence level are established. The measured power spectra of the turbulence are consistent with Kolmogoroff scaling for

$k\eta > 0.1$, where k is the wave number, and η is the Kolmogoroff length; but, for $k\eta < 0.1$, the spectra of the stream-wise turbulence velocity component and of the cross-stream component do not appear to be isotropically related. However, the stream-wise spectrum does display a $-\frac{5}{3}$ region, which increases in extent with increasing Reynolds number.

Kizner, W.

K11 ERROR CURVES FOR LANCZOS' "SELECTED POINTS" METHOD

Kizner, W.

Technical Report 32-703 (Unclassified)

(Reprinted from *The Computer Journal*, Vol. 8, No. 4, January 1966, pp. 372-381)

The solution of ordinary differential equations by polynomials is discussed from the point of view of constructive function theory. This Report shows how to obtain two new families of "selected points": one tending to minimize the absolute maximum error of the solution, and the other tending to minimize the absolute value of the error at the final time point.

Klevans, E. H.

K12 ANALYSIS AND APPLICATION OF THE DIELECTRIC CONSTANT OF A TWO-TEMPERATURE PLASMA

Klevans, E. H., Primack, J. R.

Technical Report 32-888, June 15, 1966

(Unclassified)

This Report discusses three problems which arise in the study of fully ionized plasmas where the electron temperature exceeds the ion temperature. For the first problem, the dielectric constant of a two-temperature plasma is analyzed to determine: (1) the conditions under which ion waves will be found, (2) accurate values for the phase velocity and damping rate of ion waves, (3) the validity of approximate expressions for the ion wave phase velocity and damping, and (4) the behavior of the dynamic shielding factor when ion waves are possible. The second problem concerns the numerical evaluation of the high-frequency conductivity of a two-temperature plasma. Approximations and their validity are discussed. Results are presented for the real part of the conductivity as a function of frequency, with the electron-to-ion temperature ratio as a parameter. For the third problem, the electrostatic energy per degree of freedom is computed. A comparison is made of numerical results obtained from approximate analytic expressions with those obtained from numerical integration of the exact expression.

K13 HIGH-FREQUENCY CONDUCTIVITY OF A PLASMA IN QUASI-EQUILIBRIUM. III. STUDY OF A TWO-TEMPERATURE PLASMA

Klevans, E. H., Wu, C.-S.

Technical Report 32-1013 (Unclassified)

(Reprinted from *The Physical Review*, Vol. 149, No. 1, September 9, 1966, pp. 141-154)

A general expression for the high-frequency conductivity of a homogeneous, isotropic plasma has been obtained. Based on the use of the Bogoliubov-Born-Green-Kirkwood-Yvon hierarchy, the derivation therefore includes all effects due to the high-frequency field and the collective interactions up to first order in the plasma parameter. As an application of the general result, a two-temperature plasma with the electron temperature exceeding the ion temperature is studied in detail. It is found that, when the ratio of the electron temperature to the ion temperature exceeds 100, there is an enhancement in the resistivity resulting from the excitation of incoherent ion waves.

Knolle, K.

K14 INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS

Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A., Patterson, J. H., Franzgrote, E.

Technical Report 32-1065 (Unclassified)

(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 12, December 1966, pp. 1681-1686)

For abstract, see Turkevich, A.

K15 CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION

Turkevich, A. L., Knolle, K., Franzgrote, E., Patterson, J. H.

Technical Report 32-1090 (Unclassified)

(Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 2, January 15, 1967, pp. 831-839)

For abstract, see Turkevich, A. L.

Kohorst, D. P.

K16 DESIGN, FABRICATION, AND TESTING OF THE APPLICATIONS TECHNOLOGY SATELLITE APOGEE MOTOR CHAMBER

Lardenoit, V. F., Wada, B. K., Kohorst, D. P.

Technical Memorandum 33-309, November 1, 1966

(Unclassified)

For abstract, see Lardenoit, V. F.

Krieve, W. F.

K17 FISSION-ELECTRIC CELL IRRADIATION

Krieve, W. F.

Technical Report 32-970, March 1, 1967

(Unclassified)

A series of capsule reactor irradiation experiments was performed to study the component behavior of fission-electric cell devices under relatively high-radiation intensity and with sufficient fuel burnup to establish operational trends. This Report gives a detailed account of these experiments, describes the design of various fission-electric cell capsules, and discusses specialized fabrication techniques. The experiments were concerned with electrical characteristics of the cells and with

the materials problems associated with extended irradiation periods. In addition to the in-pile measurements of cell performance (as well as calibration runs in intense gamma fluxes), the experiments included extensive post-irradiation, microscopic, and radiochemical analyses.

K18 JPL FISSION-ELECTRIC CELL EXPERIMENT

Krieve, W. F.

Technical Report 32-981, November 15, 1966

(Unclassified)

A series of experiments was performed with two, different, large, concentric, cylindrical fission-electric cells in thermal neutron fluxes up to 10^{10} neutrons/cm²-sec at the General Electric Nuclear Test Reactor, Vallecitos, California. A clear-cut demonstration of the fission-electric cell concept was achieved. Fission fragment currents up to 10^{-8} amp, which were in good agreement with calculated values, were observed. Magnetic-field suppression of electron counter-currents was completely successful; however, electrostatic grid suppression of the extraneous electrons was much less effective.

The original cell configuration, in which the anode cylinder surrounded the inner cathode cylinder, achieved stable potentials of approximately 1 kv. The modified configuration, in which the cathode with electron sweep rings surrounded the anode, reached potentials as large as 21 kv, but was not stable above 4 kv.

Lamers, M. D.

L01 OCTAVE AND ONE-THIRD OCTAVE ACOUSTIC NOISE SPECTRUM ANALYSIS

Hayes, C. D., Lamers, M. D.

Technical Report 32-1052, January 15, 1967

(Unclassified)

For abstract, see Hayes, C. D.

Lance, T. A.

L02 ANALYSIS OF PROPELLANT SLOSH DYNAMICS AND GENERATION OF AN EQUIVALENT MECHANICAL MODEL FOR USE IN PRELIMINARY VOYAGER AUTOPILOT DESIGN STUDIES

Lance, T. A.

Technical Memorandum 33-306, December 1, 1966

(Unclassified)

The linearized dynamic equations of propellant motion in the regime dominated by gravity force have been developed for a cylindrical tank approximation of the lunar excursion module descent system (LEMDS) propellant tanks. An equivalent mechanical model consisting of a fixed mass and an infinite series of springs and masses has been generated. A computer program has been developed to calculate the parameters required to describe the equivalent mechanical model for an assumed spacecraft flying an assumed mission profile. These parameters are presented as a function of time for three mission profiles and can be used for preliminary analysis of *Voyager*

closed-loop autopilot designs. Transfer functions for the propellant dynamics are also presented.

Landel, R. F.

L03 SOME EFFECTS OF FILLERS ON THE DEFORMATION AND RUPTURE OF AN ELASTOMER

Landel, R. F.

Technical Report 32-922 (Unclassified)

(Reprinted from *Mechanics and Chemistry of Solid*

Propellants, Pergamon Press, New York, 1966, pp. 575-614)

The addition of a filler changes the mechanical behavior of amorphous gum elastomers in several ways. One of the most thoroughly investigated changes is that in the small-strain modulus as a function of filler content. An explicit expression for relative modulus may be obtained, and an upper and lower bound. At higher strains, the rubber tends to rupture internally. At increasing strains, the void usually advances to the surface of the particle and the rubber pulls away from the surface in a dewetting phenomenon. At very high loadings, or with particles which interact strongly with each other, it may be necessary to consider the contribution of particle-particle interaction forces to the overall behavior.

In spite of these complications introduced by the filler, many of the characteristics of the fracture behavior of pure rubbers persist in the two-phase system. On the other hand, the presence of the filler provides an upper bound to a strain failure criterion, since lateral contractions are possible only up to the maximum packing density of the particles.

L04 SOME EXPERIMENTAL OBSERVATIONS ON THE STORED ENERGY FUNCTION FOR SMALL VALUES OF STRAIN INVARIANTS

San Miguel, A., Landel, R. F.

Technical Report 32-1006 (Unclassified)

(Reprinted from *Transactions of the Society of Rheology*, Vol. 10, No. 1, 1966, pp. 369-383)

For abstract, see San Miguel, A.

Lang, T. E.

L05 SUMMARY OF THE FUNCTIONS AND CAPABILITIES OF THE STRUCTURAL ANALYSIS AND MATRIX INTERPRETIVE SYSTEM COMPUTER PROGRAM

Lang, T. E.

Technical Report 32-1075, April 1, 1967 (Unclassified)

The functions and capabilities of a large-capacity structural analysis and matrix interpretive system (SAMIS) digital computer program developed to analyze frame and shell-type structures are described. Included is a description of each sub-program function with associated time-performance capabilities defined, as established by program usage at a particular computer installation. Program development considerations given to modularization of the program for functionally-diverse applications and reduction of errors in program usage are outlined.

**L06 STRUCTURAL ANALYSIS AND MATRIX
INTERPRETIVE SYSTEM (SAMIS) USER REPORT**

Lang, T. E.

Technical Memorandum 33-305, March 1, 1967

(Unclassified)

This Memorandum describes the application and user aspects of the structural analysis and matrix interpretive system (SAMIS) computer program. Included are detailed descriptions of: (1) element data preparation, (2) matrix manipulations by use of "pseudo instructions," (3) solution printout in solving the problem of a shallow spherical shell under thermal and pressure loadings and the calculation of the natural modes and frequencies of the shell, (4) "pseudo instructions" for matrix partitioning, and (5) structural partitioning and matrix reduction techniques.

Lardenoit, V. F.

**L07 DESIGN, FABRICATION, AND TESTING OF THE
APPLICATIONS TECHNOLOGY**

SATELLITE APOGEE MOTOR CHAMBER

Lardenoit, V. F., Wada, B. K., Kohorst, D. P.

Technical Memorandum 33-309, November 1, 1966

(Unclassified)

When fired, the apogee motor of the *Applications Technology Satellite* provides the necessary impulse to place the satellite in a near-synchronous orbit. An optimum design for the chamber was achieved by a team effort among materials, structures fabrication, propulsion, and design personnel. The chamber, made from Ti-6 Al-4 V alloy, consists of two half-shells and a mounting ring. Fabrication was accomplished by forging to shape, machining to the desired thickness, and welding of components. Verification of chamber design was obtained through hydroburst, vibration, and acceleration tests. Details of the materials selection, design, required tradeoffs, fabrication, and testing of the motor chambers are discussed in this Memorandum.

Laue, E. G.

**L08 PYRHELIOMETRIC COMPARISONS AT THE JPL
TABLE MOUNTAIN FACILITY**

Drummond, A. J., Laue, E. G.

Technical Memorandum 33-312, December 15, 1966

(Unclassified)

For abstract, see Drummond, A. J.

L09 NASA IN-HOUSE REPORT OF SSME OPERATIONS

Laue, E. G.

Technical Memorandum 33-318, December 15, 1966

(Unclassified)

This Report of the Solar Spectrum Measurement Experiment (SSME) operations describes a flight-qualified, 12-channel filter-type spectroradiometer developed by Eppley Laboratory, associated electronic signal-conditioning equipment and X-15 pod developed by JPL, and the JPL/Eppley joint flight operations. Preliminary results of measurements

made using the NASA Lewis Research Center B-57 aircraft at altitudes between 10,000 and 47,000 ft are presented. The one flight made to date by the X-15-III at altitudes of 180,000 to 240,000 ft is described, as are problems inherent in using this sophisticated aircraft for testing.

Layman, W. E.

**L10 THE DESIGN AND TESTING OF AN INFLATED
SPHERE IMPACT LIMITER**

Ross, R. G., Jr., Layman, W. E.

Technical Report 32-1037, December 15, 1966

(Unclassified)

For abstract, see Ross, R. G., Jr.

Lee, T. P.

L11 IGNITION SYSTEM FOR THE ATS ROCKET MOTOR

Lee, T. P.

Technical Memorandum 33-317, February 1, 1967

(Unclassified)

This Memorandum documents the design, development, testing, and qualification of an igniter system for the solid-propellant *Application Technology Satellite* (ATS) apogee rocket motor. The development phase started with a scaled-up model of the *Syncom I* igniter and rapidly progressed to an internally insulated aluminum basket with 12 gas ports and a pyrotechnic charge of 19 ALCLO pellets and two solid-grain ALCLO main grain charges. The ALCLO ignition material consists of aluminum fuel, potassium perchlorate oxidizer, and suitable additives for binding, stabilization, and burning-rate control. The igniter interfaces to either a development closure for data acquisition or to a safe-and-arm (S&A) device for flight and qualification testing. Ignition of the pyrotechnic charge is initiated by either a single dual-bridgewire squib for development testing or two single bridgewire squibs when used with the S&A device. The igniter, less closure or S&A, weighs 1 lb.

Leighton, R. B.

L12 THE PHOTOGRAPHS FROM MARINER IV

Leighton, R. B.

Technical Report 32-958 (Unclassified)

(Reprinted from *Scientific American*, Vol. 214, No. 4, April 1966, pp. 54-68)

How the photographs from *Mariner IV* were made and what they show is reviewed in this Report. This is the second of three articles on the remarkably successful *Mariner* mission.

Leipold, M. H.

L13 SURFACE ADSORPTION IN MAGNESIUM OXIDE

Nielsen, T. H., Leipold, M. H.

Technical Report 32-949, June 1, 1966

(Unclassified)

For abstract, see Nielsen, T. H.

L14 IMPURITY DISTRIBUTION IN MgO

Leipold, M. H.

Technical Report 32-1015 (Unclassified)

(Reprinted from the *Journal of the American Ceramic Society*, Vol. 49, No. 9, September 1966, pp. 498-502)

Microprobe studies were conducted on hotpressed polycrystalline MgO compacts, nominally 99.5 and 99.95% pure. Results indicated that in MgO some common impurities, such as Al, Ca, and Si, when present in amounts as small as 30 atomic ppm, were segregated to grain boundaries. Mutually incompatible segregated phases existed at the grain boundaries. Other impurities such as Fe appeared to be uniformly distributed. Although some impurity agglomeration was noted, it was not required for impurity segregation. The presence of such agglomerates would complicate the problems of chemical analysis.

L15 A STUDY OF THE STRUCTURE OF GRAIN BOUNDARIES IN POLYCRYSTALLINE MAGNESIUM OXIDE

Smyth, H. T., Leipold, M. H.

Technical Report 32-1042, April 15, 1967

(Unclassified)

For abstract, see Smyth, H. T.

Levy, G. S.**L16 GROUND INSTRUMENTATION FOR MARINER IV OCCULTATION EXPERIMENT**

Levy, G. S., Otschi, T. Y., Seidel, B. L.

Technical Report 32-984, September 15, 1966

(Unclassified)

The *Mariner IV* occultation experiment imposed unique requirements upon the NASA/JPL Deep Space Instrumentation Facility. It was necessary to measure extremely small deviations in the rate of change of frequency to a few parts in 10^{10} . The instrumentation used and the results obtained are described.

Lieske, J.**L17 EXPRESSIONS FOR THE PRECESSION QUANTITIES AND THEIR PARTIAL DERIVATIVES**

Lieske, J.

Technical Report 32-1044, June 15, 1967

(Unclassified)

The purpose of this Report is to investigate the functional dependence of precession quantities such as ζ_0 , z , θ upon the fundamental constants. The effect of small changes of the fundamental constants upon the precession quantities is derived, and numerical partial derivatives are given as power series in time from an arbitrary epoch.

Lindsey, W. C.**L18 IMPROVEMENTS TO BE REALIZED THROUGH THE USE OF BLOCK-CODED COMMUNICATION SYSTEMS**

Lindsey, W. C.

Technical Report 32-947 (Unclassified)

(Reprinted from *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-2, No. 3, May 1966, pp. 364-366)

The purpose of this Report is to present a result which will aid the communications engineer in determining the effect which a noisy carrier reference has on the detection process. The result also demonstrates the relative practical improvements to be realized from "single-channel" block-coded systems. By "single-channel" is indicated a system in which the data signal and the synchronization signal are embodied into a composite code which, in turn, is used to phase modulate the radio frequency carrier. For such a system *all* of the available transmitter side-band power is allocated to it.

L19 PHASE-SHIFT-KEYED SIGNAL DETECTION WITH NOISY REFERENCE SIGNALS

Lindsey, W. C.

Technical Report 32-968 (Unclassified)

(Reprinted from *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-2, No. 4, July 1966, pp. 393-401)

This paper derives and graphically illustrates the performance characteristic of Phase-Shift-Keyed communication systems where the receiver's phase reference is noisy and derived from the observed waveform by means of a narrow-band tracking filter (a phase-locked loop). In particular, two phase measurement methods are considered. One method requires the transmission of an auxiliary carrier (in practice, this signal is usually referred to as the sync subcarrier). This carrier is tracked at the receiver by means of a phase-locked loop, and the output of this loop is used as a reference signal for performing a coherent detection. The second method is self-synchronizing in that the reference signal is derived from the modulated data signal by means of a squaring-loop.

The statistics (and their properties) of the differenced-correlator outputs are derived and graphically illustrated as a function of the signal-to-noise ratio existing in the tracking filter's loop bandwidth and the signal-to-noise ratio in the data channel. Conclusions of these results as well as design trends are presented.

L20 OPTIMAL DESIGN OF ONE-WAY AND TWO-WAY COHERENT COMMUNICATION LINKS

Lindsey, W. C.

Technical Report 32-988 (Unclassified)

(Reprinted from *IEEE Transactions on Communication Technology*, Vol. Com-14, No. 4, August 1966, pp. 418-431)

This paper is concerned with the optimal design of one-way and two-way communication systems which are of greatest interest in space applications. A two-way communication system is defined to be one composed of two radio links or channels, viz., an up-link channel and a down-link channel. The down-link RF carrier is derived from the carrier tracking loop located in the up-link receiver. Transmission of information which does not make use of the carrier derived in the up-link receiver is referred to as one-way communication.

In particular, a design technique is presented in the form of a universal set of design curves which enable the communications engineer to make a "best" choice of parameters when faced with a given set of design constraints. This means that, given a certain desired error probability, a total transmitter power limitation, data rate, and carrier tracking loop bandwidth, the modulation index, i.e., the square root of the ratio of the power in the carrier to the total transmitted power, may be chosen so as to minimize the probability of error.

As an alternate technique, and one which is not as difficult to carry out, the design may be predicted on the basis of selecting that value of modulation index which maximizes the signal-to-noise ratio at the output of the data demodulator. Design curves are given which allow one to employ this alternate criterion. Further, these results should prove useful when attempting to check experimentally a design based upon the criterion of minimum error probability.

- L21 A MODEL DISTRIBUTION FOR THE PHASE ERROR IN SECOND-ORDER PHASE-LOCKED LOOPS**
Lindsey, W. C., Charles, F. J.
Technical Report 32-1017 (Unclassified)
(Reprinted from *IEEE Transactions on Communication Technology*, Vol. COM-14, No. 10, October 1966, pp. 662-664)

Experimental results relative to the distribution and properties of the phase error in a second-order phase-locked loop (PLL) are given. These measurements are used to complement the analytical model in a signal-to-noise region where the linear PLL theory does not apply. Compared to the actual measurements of the second-order loop performance, it is shown that this model distribution provides excellent agreement over the useful range of most phase-locked receivers.

- L22 ERROR PROBABILITIES FOR PARTIALLY COHERENT DIVERSITY RECEPTION**
Lindsey, W. C.
Technical Report 32-1024 (Unclassified)
(Reprinted from *IEEE Transactions on Communication Technology*, Vol. COM-14, No. 5, October 1966, pp. 620-625)

The probability that an ideal coherent receiver errs in receiving a noisy N -ary orthogonal transmission through M independent slow Rician fading channels is derived. The receiver to be analyzed coalesces coherent and noncoherent reception. A more easily implemented, linearized version of the same

receiver is presented, and the performance of both is compared with a previously analyzed noncoherent detector.

For small random channel components, the linearized receiver performs almost identically with the optimum receiver. Neglecting the information contained in the random component shows up as an additional noise component in the output and there exists an irreducible error probability, even in the absence of the additive disturbance, which depends on the ratio of the energy received via the specular channel components to the mean squared value of the scatter components. Thus, the importance of using the information conveyed via the channel scatter components is clearly manifested.

- L23 SOME ANALYTICAL AND EXPERIMENTAL PHASE-LOCKED LOOP RESULTS FOR LOW SIGNAL-TO-NOISE RATIOS**
Charles, F. J., Lindsey, W. C.
Technical Report 32-1027 (Unclassified)
(Reprinted from the *Proceedings of the IEEE*, Vol. 54, No. 9, September 1966, pp. 1152-1166)

For abstract, see Charles, F. J.

Loomis, A. A.

- L24 A METHOD FOR OBTAINING THE RADIUS OF MARS**
Loomis, A. A., Bourke, R. D., DeBra, D. B.
Technical Report 32-1091 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 4, February 15, 1967, pp. 1265-1268)

Three related unknowns of major scientific interest concerning Mars are the size and the shape of the planet and the extent of surface topographic relief. Both local topographic relief and continental-scale topographic differences can be considered, along with the planetary ellipticity, as differences among the distances from the center of a planet to various points on the surface. The scientific value of determining the radius to a landed payload is discussed and a method for measuring the radius is suggested. By measuring the gravity field strength at the surface of the planet to an accuracy of 1 part in 10^4 , it is possible to infer the radius to 1 km.

Lorell, J.

- L25 COMPRESSED TRACKING DATA USED FOR FIRST ITERATION IN SELENODESY EXPERIMENT, LUNAR ORBITER I AND II**
Lorell, J., Sjogren, W. L., Boggs, D.
Technical Memorandum 33-343, May 1, 1967
(Unclassified)

This Report describes briefly the method of data compression used for the tracking data analysis of the NASA *Lunar Orbiters*, and gives tables and graphs of the compressed data for the orbit of *Lunar Orbiter I*, and for part of the orbit of *Lunar Orbiter II*.

Lorens, C. S.

L26 NONLINEAR CHARACTERISTICS OF PULSE-DURATION MODULATION

Lorens, C. S.

Technical Report 32-1069, February 15, 1967
(Unclassified)

A comparison of pulse-duration demodulation with pulse-code demodulation indicates that there is a pulse-code modulation (PCM) system that will outperform any pulse-duration modulation (PDM) system by input power levels of about 2.5, 4.5, and 7 db at 20-, 30-, and 40-db output signal-to-noise ratios, respectively. However, the PDM systems outperform the PCM systems at a sufficiently high input signal-to-noise density ratio. Thus, PDM tends to make better use of high signal strengths, while PCM makes better use of low signal strengths.

Ludwig, A. C.

L27 RADIATION PATTERN SYNTHESIS FOR CIRCULAR APERTURE HORN ANTENNAS

Ludwig, A. C.

Technical Report 32-895 (Unclassified)

(Reprinted from *IEEE Transactions on Antennas and Propagation*, Vol. AP-14, No. 4, July 1966, pp. 434-440)

A set of radiation pattern functions, suitable for synthesis of radiation patterns from circular-aperture horn antennas, is obtained by assuming an aperture distribution consisting of the fields of cylindrical waveguide modes. A technique is presented for using a linear combination of the radiation pattern functions to approximate a desired radiation pattern. Linear combinations of the radiation pattern functions, resulting in maximum secondary gain when used to illuminate a paraboloidal antenna, are obtained empirically. Using spherical wave theory, the maximum performance theoretically obtainable from an antenna is derived as a function of the aperture size of the feed system; the feed efficiency resulting from these theoretical limits on performance is compared to the feed efficiency of patterns obtainable from circular-aperture horn antennas and to experimental results of attempts to realize optimum circular-aperture horn patterns.

L28 COMPUTER PROGRAMS FOR ANTENNA FEED SYSTEM DESIGN AND ANALYSIS VOLUME I. PROGRAMS AND SAMPLE CASES

Ludwig, A. C.

Technical Report 32-979, April 15, 1967
(Unclassified)

A library of computer programs for antenna feed system design and analysis is described, with emphasis on instructions for using the programs. The programs cover a large spectrum of feed design problems, from primary feed pattern synthesis to the far-field pattern of the main reflector, including analyses of structural distortions.

L29 COMPUTER PROGRAMS FOR ANTENNA FEED SYSTEM DESIGN AND ANALYSIS VOLUME II. PROGRAM LISTINGS

Ludwig, A. C.

Technical Report 32-979, April 15, 1967
(Unclassified)

A library of computer programs for antenna feed system design and analysis is listed. The programs cover a large spectrum of feed design problems, from primary feed pattern synthesis to the far-field pattern of the main reflector, including analyses of structural distortions. Program descriptions, discussions of applications, and samples of input and output data are given in Volume I of this Report.

Lurie, S. M.

L30 ON THE APPLICATION OF EXTREME-VALUE STATISTICS TO COMMAND ORIENTED PROBLEMS

Ashlock, J. C., Lurie, S. M.

Technical Report 32-1025, October 15, 1966
(Unclassified)

For abstract, see Ashlock, J. C.

Lushbaugh, W. A.

L31 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES (REVISION 1)

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.

Technical Report 32-772 (Unclassified)

(Reprinted from *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-3, No. 1, January 1967, pp. 57-65)

For abstract, see Anderson, T. O.

Lyttleton, R. A.

L32 DYNAMIC CAPTURE OF THE MOON BY THE EARTH

Lyttleton, R. A.

Technical Report 32-1020, November 15, 1966
(Unclassified)

Numerical integrations of dynamical equations relating to the Sun, Earth, and Moon have been carried out to determine conditions under which the Moon could be temporarily captured from an independent planetary orbit to become an Earth satellite. The period of time $2T$ (T = time of escape) for which it would remain captured depends critically on the solar eccentricity and on the major-axis and eccentricity of the lunar orbit. This orbit becomes unstable, in the sense that the Moon would eventually escape, if either the lunar distance a or the lunar eccentricity e is increased beyond certain limits. The dependence of T on the initial values of a and e and the paths of the Moon relative to the Sun and the Earth in its motion of escape are shown in diagrams. Possible sources of dissipative action that could render such temporary dynamical capture permanent are briefly discussed.

McClatchey, R. A.

Mc01 BALLOON OBSERVATIONS OF THE RADIANCE OF THE EARTH BETWEEN 2100 cm^{-1} AND 2700 cm^{-1}
Shaw, J. H., McClatchey, R. A., Schaper, P. W.
Technical Report 32-1080 (Unclassified)
(Reprinted from *Applied Optics*, Vol. 6, No. 2, February 1967, p. 227)

For abstract, see Shaw, J. H.

McDonald, W. S.

Mc02 VENUS/MERCURY SWINGBY WITH VENUS CAPSULE: PRELIMINARY SCIENCE OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES
Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S., Barath, F. T., Herriman, A. G., Goforth, L.
Technical Memorandum 33-332, May 1, 1967 (Unclassified)

For abstract, see Brereton, R. G.

McKeethen, R.

Mc03 DIGITAL TO ANALOG PULSER SYSTEM FOR TESTING PULSE HEIGHT ANALYZERS
Gardner, F. M., McKeethen, R.
Technical Report 32-1049 (Unclassified)
(Reprinted from *Nuclear Instruments and Methods*, Vol. 46, North-Holland Publishing Co., 1967, pp. 121-124)

For abstract, see Gardner, F. M.

Mack, T. H.

M01 SEPARATION OF TWO BODIES IN SPACE - A MACHINE PROGRAMMED ANALYSIS USING THE LAGRANGE EQUATIONS AND EULERIAN ANGLES
Mack, T. H., Chamberlain, R. G.
Technical Report 32-912, May 15, 1966
(Unclassified)

This Report presents a development of the Lagrange equations of motion and a FORTRAN computer program for the motion of two rigid bodies in space separating as a result of any one, or a combination of, the following force mechanisms: springs with ball ends, springs with one end guided, pyrotechnics, rockets, cold-gas jets, air pistons, and coulomb drag. Two constraints, treated by the method of Lagrange multipliers, are included as options. These constraints are: (1) the *pin-puller delay*, which represents the situation when one discrete separation device (e.g., a pin puller) actuates later than the others, providing a ball-and-socket type of joint prior to final separation-device firing; and (2) the *hard-mounted spring constraint*, which takes into account the fact that sliding, at the tip of a guided spring, is usually prohibited either by design or by inherent friction. The forces arising from the various mechanisms are represented by the customary math-

ematical models. No approximations are used in the derivation of the classical equations of motion; the equations are numerically integrated by the Adams-Moulton method.

Manatt, S. L.

M02 NUCLEAR MAGNETIC RESONANCE OF PHOSPHORUS COMPOUNDS. II. THE RELATIVE SIGNS OF THE SPIN-SPIN COUPLINGS IN DIMETHYLPHOSPHINE AND METHYLPHOSPHINE
Manatt, S. L., Juvinal, G. L., Wagner, R. I., Elleman, D. D.
Technical Report 32-974 (Unclassified)
(Reprinted from *Journal of the American Chemical Society*, Vol. 88, No. 12, June 20, 1966, pp. 2689-2697)

From nmr ^1H - ^1H decoupling experiments at 60 Mc, the P-H and P-C-H couplings in dimethylphosphine (I) and methylphosphine (II) were determined to have the same sign. Double resonance ^1H - ^{31}P experiments on I at 40 and 16.2 Mc, respectively showed that the P-C-H and H-C-P-H couplings have the same sign. Analyses of the ^{31}P nmr spectra of I and II at 24.3 Mc showed that the P-C-H, P-C-C-H, and P-H couplings in these molecules have the same relative sign. These results are discussed in light of other reported relative sign determinations of coupling constants involving ^{31}P and ^1H and a correlation of the absolute signs of phosphorus-31-proton couplings is presented. The relation of the magnitudes and the signs of the P-C-H couplings to the s character of the carbon and phosphorus bonding orbitals is discussed.

Mankovitz, R. J.

M03 DIANA: A DIGITAL-ANALOG SIMULATION PROGRAM FOR THE IBM 1620 II COMPUTER
Mankovitz, R. J.
Technical Report 32-1011, Revision 1, March 1, 1967
(Unclassified)

DIANA is a block-oriented interpretive program which can be used to simulate physical systems by solving the simultaneous differential equations describing the systems. The program behaves much like an analog computer, with on-line control and input-output capabilities. Available DIANA integration methods include: fifth-order Adams-Moulton, with adaptive step size; fixed-step Adams; and Runge-Kutta-Gill.

M04 THE ANALYSIS AND CONFIGURATION OF A CONTROL SYSTEM FOR A MARS PROPULSIVE LANDER
Mankovitz, R. J.
Technical Report 32-1104, March 15, 1967
(Unclassified)

A control-system mechanization for a planetary propulsive lander is studied. This is a soft-landing descent system that combines inertial and radar sensing techniques to control the capsule from motor ignition to touchdown on the surface of a planet. A digital computer is the basic tool for analysis and simulation of the system and its environment.

Marjaniemi, D.

**M05 WAVEFRONTS AND CONSTRUCTION TOLERANCES
FOR A CAT'S-EYE RETROREFLECTOR**

Beer, R., Marjaniemi, D.

Technical Report 32-983 (Unclassified)

(Reprinted from *Applied Optics*, Vol. 5, No. 7,
July 1965, p. 1191)

For abstract, see Beer, R.

Martin, H. C.

**M06 LARGE DEFLECTION AND STABILITY ANALYSIS
BY THE DIRECT STIFFNESS METHOD**

Martin, H. C.

Technical Report 32-931, August 1, 1966

(Unclassified)

The application of the direct stiffness method in the solution of large deflection and stability problems is demonstrated. Discussed first are the basic elasticity equations that contain higher order terms to account for the nonlinear character of large deflections and large rotations. Various simplifications of these equations are made, and the conditions and limitations of the resulting expressions are discussed.

Examples of geometrically nonlinear systems are presented to illustrate the importance of considering the nonlinear behavior in many problems.

The modifications to the stiffness matrix, and the method of formal solution are derived for some of the nonlinear examples that have been discussed.

Maserjian, J.

**M07 CONDUCTION THROUGH THIN TITANIUM
DIOXIDE FILMS**

Maserjian, J.

Technical Report 32-976, October 1, 1966

(Unclassified)

Conduction through TiO_2 films of thickness 100–450 Å has been investigated. The samples were prepared by either anodization of Ti or evaporation of TiO_2 , with Au or Al evaporated for contacts. The anodized samples exhibited considerable hysteresis due to electrical forming; however, it was possible to avoid this problem with the evaporated samples from which complete sets of experimental results were obtained and used in the analysis. Electrical measurements included: the dependence of current and capacitance on dc voltage and temperature; the dependence of capacitance and conductance on frequency and temperature; and transient measurements of current and capacitance. A thick (3000 Å) evaporated TiO_2 film was used for measuring the dielectric constant (27.5) and the optical dispersion, the latter being similar to that for rutile. An electron-transmission diffraction pattern of an evaporated film indicated an essentially amorphous structure with a short range order that could be related to rutile. Photo-response measurements

indicated the same band gap of about 3 eV for anodized and evaporated films and reduced rutile crystals, and gave the barrier energies at the contacts.

Massier, P. F.

**M08 SOME OBSERVATIONS ON REDUCTION OF
TURBULENT BOUNDARY-LAYER HEAT TRANSFER
IN NOZZLES**

Back, L. H., Massier, P. F., Cuffel, R. F.

Technical Report 32-1056 (Unclassified)

(Reprinted from *AIAA Journal*, Vol. 4, No. 12,
December 1966, pp. 2226–2229)

For abstract, see Back, L. H.

Melbourne, W. G.

**M09 THE CONJUGATE POINT AND DYNAMIC
PROGRAMMING**

Melbourne, W. G.

Technical Report 32-1043, September 15, 1966
(Unclassified)

The continuity properties of the second partials of the optimal performance function $S(x, y)$ play a crucial role in making the transition from the recursive formulation of the principle of optimality of dynamic programming to the Hamilton–Jacobi equation and to the Euler and Weierstrass necessary conditions of the calculus of variations. At a singularity point of an extremal, S_{yy} has a first-order pole. The asymptotic properties of S_{yy} near a pole are discussed and used to demonstrate the necessity of the boundedness of S_{yy} on the interior of a minimizing extremal. A one-to-one relationship is demonstrated between a pole of S_{yy} on the interior of an extremal and the conjugate point as classically defined in the calculus of variations. The geometric properties of envelopes and the envelope theorem are reviewed. Finally, it is shown that, when the end point of an extremal is sufficiently close to an envelope, such an extremal is not a globally minimizing curve.

Melosh, R. J.

**M10 STRUCTURE ANALYSIS AND MATRIX
INTERPRETIVE SYSTEM (SAMIS)
PROGRAM REPORT**

Melosh, R. J., Diether, P. A., Brennan, M.

Technical Memorandum 33-307, September 1, 1966
(Unclassified)

This Report describes the computer aspects of the Structural Analysis and Matrix Interpretive System (SAMIS). It includes a general description of system components and their function, operational, flow, and program intelligence. It describes data and program identification, formats, and handling. It defines system tape and core assignments. It includes writeups of each of the subprograms and discusses requirements for preparing input data.

The theoretical basis for the program is contained in a companion report entitled "Structural Analysis and Matrix Interpretive System—Technical Report."

- M11 STRUCTURAL ANALYSIS AND MATRIX INTERPRETIVE SYSTEM (SAMIS) PROGRAM REPORT (REVISION 1)**
Melosh, R. J., Diether, P. A., Brennan, M.
Technical Memorandum 33-307, December 15, 1966
(Unclassified)

This Memorandum describes the computer aspects of the structural analysis and matrix interpretive system (SAMIS), including data and program identification, formats, and handling. A general description of system components, their function, operations, flow, and program intelligence is also included. System tape and core assignments are defined, writeups of each of the subprograms are shown, and requirements for preparing input data are discussed. The theoretical basis for the programs is described in *Structural Analysis and Matrix Interpretive System (SAMIS) Program: Technical Report*, Technical Memorandum 33-311 (see Prerelease for November 1966).

- M12 STRUCTURAL ANALYSIS AND MATRIX INTERPRETIVE SYSTEM (SAMIS) PROGRAM: TECHNICAL REPORT**
Melosh, R. J., Christiansen, H. N.
Technical Memorandum 33-311, November 1, 1966
(Unclassified)

This Report describes the technical basis for programs contained in the Structural Analysis and Matrix Interpretive System (SAMIS). Development of the stiffness, stress, loading, and transformation relations for representation of a structure by a collection of flat triangular shell facets, rods, beams, and tubes is discussed, as are the definition for the basis for special and complex program links and the use of these programs for structural analysis. A discourse on the analysis error in formulating the mathematical model of and in analyzing a structure is presented.

Metz, T. R.

- M13 STORAGE TESTS OF NITROGEN TETROXIDE AND HYDRAZINE IN ALUMINUM CONTAINERS**
Hollywood, L. P., Metz, T. R., Porter, R. N.
Technical Report 32-1039, January 15, 1967
(Unclassified)

For abstract, see Hollywood, L. P.

Moacanin, J.

- M14 NON-RANDOMNESS IN BASE SEQUENCES OF DNAs**
Moacanin, J., Simha, R.
Technical Report 32-972 (Unclassified)
(Reprinted from *Biochemical and Biophysical Research Communications*, Vol. 23, No. 5, 1966, pp. 592-599)

Experimental analyses of sequences in a series of natural and synthetic DNAs have led investigators to the conclusion that the arrangement of the four bases in the chain departs significantly from a random distribution. A statistical analysis showed that sequence data for a copolymer of adenine and uracil as well as for calf thymus DNA must be interpreted on the basis of higher than nearest neighbor effects. That is, the frequency of occurrence of a specific base arrangement cannot be predicted from the composition alone, but has to be expressed in terms of conditional probabilities which describe departures from randomness.

Detailed consideration is given to Petersen's recent results on calf thymus DNA, which are more extensive than those analyzed previously. Some results on other animal, plant, and bacterial DNAs are discussed in support of the generality of the conclusions.

- M15 SOME CONSEQUENCES OF THE GIBBS-DIMARZIO THEORY OF THE GLASS TRANSITION**
Moacanin, J., Simha, R.
Technical Report 32-992 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 45, No. 3, August 1966, pp. 964-967)

Using the Gibbs-DiMarzio theory of the glass transition, an expression has been derived from the Simha-Boyer parameter $K_1 = (\alpha_L - \alpha_G)T_G$, which is a function only of the fractional unoccupied volume at T_2 (i.e., $K_1 = -V_0 \ln V_0$). The analysis of the theory shows that T_2 is proportional to the chain stiffness parameter ϵ and is zero for a chain of zero stiffness. Wide variations in the intermolecular energy parameter E_0 effect relatively minor changes in T_2 and, hence, T_G . However, for values of ϵ smaller than E_0 , the theory predicts the absence of the discontinuity in the volume expansivities normally observed at T_G . Furthermore, the available experimental results indicate that ϵ and E_0 may not be independent parameters, as originally defined.

- M16 EFFECT OF POLAR FORCES ON THE VISCOELASTIC PROPERTIES OF POLY (PROPYLENE OXIDE)**
Moacanin, J., Cuddihy, E. F.
Technical Report, 32-1026 (Unclassified)
(Reprinted from *Journal of Polymer Science: Part C*, No. 14, 1966, pp. 313-322)

When lithium perchlorate is dissolved in ethers, volume contractions are observed which are caused by strong interaction forces between the field of Li^+ and polarizable ether oxygens. The effect of these forces on the viscoelastic properties of both low and high molecular weight/poly(propylene oxide), containing varying amounts of dissolved lithium perchlorate, was investigated by means of dilatometric, modulus, and damping constant measurements over a temperature range between -80 and 80°C . The studies verified that polar interaction forces between ether oxygens and lithium perchlorate play a major role in modifying the viscoelastic properties of poly(propylene oxide), by causing changes in both the glass transition temperature and the relaxation spectra.

M17 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.

I. ELECTRON TRANSFER FROM SODIUM TO POLY-4-VINYLBIPHENYL AND POLYVINYLNAPHTHALENES

Rembaum, A., Moacanin, J., Haack, R.

Technical Report 32-1054, Part I (Unclassified)

(Reprinted from *Journal of Micromolecular Chemistry*, Vol. 1, No. 4, October 1966, pp. 657-672)

For abstract, See Rembaum, A.

Mokski, D. J.

M18 FLUID SYSTEMS DESIGN CONCEPT FOR A LARGE GAS-COOLED FISSION-ELECTRIC CELL REACTOR SPACE POWER PLANT

Mokski, D. J.

Technical Memorandum 33-283, February 1, 1967

(Unclassified)

The possibility of using a gas to transport waste heat from a large fission-electric cell reactor directly to a radiator is examined to obtain an estimate of: (1) the pumping power required for such a system; (2) the size and weight of the reactor, radiator, and other major components; and (3) temperature distributions in the core and other parts of the system. Also, since recent calculations have shown that long core endurance (10,000 hr) might be achieved with the aid of highly loaded driver fuel modules, a separate coolant circuit is assumed for removing heat energy from this portion of the core and converting it to electrical power for pumping and auxiliary power by means of a Rankine cycle. This auxiliary power supply would employ turbine-driven alternators and a condensing radiator operating at a considerably lower temperature than the primary radiator mentioned above, but with only a fraction of the heat load carried by the coolant loop for the fission-electric cell portion.

The sizes and weights of the major components of the auxiliary power system are also estimated. An over-all specific weight of about 6.9 to 13.0 lb/kw(e), not including shields, is obtained, depending on the conversion efficiency: the higher weight corresponds to 5% conversion efficiency; the lower, to 10% conversion efficiency. As might be expected, the radiator is found to be the largest and heaviest single component. However, due to the fact that the fission-electric cell power conversion concept does not require a temperature differential between anode and cathode to produce power, the advantage in being able to radiate at a higher temperature is found to result in a potential reduction in radiator area of from 50 to 80% (depending on efficiency), as compared with that required for a comparable plant operating on a thermodynamic power-conversion cycle.

Montgomery, D. R.

M19 THE SURVEYOR LUNAR LANDING TELEVISION SYSTEM

Montgomery, D. R., Wolf, F. J.

Technical Report 32-1008 (Unclassified)

(Reprinted from *IEEE Spectrum*, August 1966, pp. 54-61)

The slow-scan television camera used in the *Surveyor I* spacecraft operates in a slow-scan mode that reduces the RF power requirements for the lunar distances involved. One 600-television-line frame is provided every 3.6 sec in normal operation; one 200-line frame is provided every 60.8 sec in a second mode of operation. Upon command from Earth, the camera's shutter opens, allowing light energy to reach a vidicon image sensor. The vidicon transduces the light energy to electric signals for subsequent transmission to Earth. Detailed calibration information obtained prior to launch permits the correction of images received for geometric nonlinearities and distortions, frequency or aperture response, photometric nonuniformities, and coherent noise.

Moore, R.

M20 HIGH-DISPERSION SPECTROSCOPIC OBSERVATION OF MARS

I. THE CO₂ CONTENT AND SURFACE PRESSURE

Spinrad, H., Schorn, R. A., Moore, R., Giver, L. P.,

Smith, H. J.

Technical Report 32-1048 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 146, No. 2, November 1966, pp. 331-338)

For abstract, see Spinrad, H.

M21 HIGH-DISPERSION SPECTROSCOPIC OBSERVATIONS OF MARS

II. THE WATER-VAPOR VARIATIONS

Schorn, R. A., Spinrad, H., Moore, R., Smith, H. J.,

Giver, L. P.

Technical Report 32-1048 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 2, February 1967, pp. 743-752)

For abstract, see Schorn, R. A.

Mulholland, J. D.

M22 LUNAR ORBITER RANGING DATA: INITIAL RESULTS

Mulholland, J. D., Sjogren, W. L.

Technical Report 32-1087 (Unclassified)

(Reprinted from *Science*, Vol. 155, No. 3758, January 6, 1967, pp. 74-76)

Data from two *Lunar Orbiter* spacecraft are used to test the significance of corrections being made to the lunar ephemeris. Range residuals of up to 1700 m are reduced by an order of magnitude by application of the corrections, with most of the

residuals reduced to less than 100 m. Removal of gross errors in the ephemeris reveals residual patterns that may indicate errors in location of observing stations, as well as the expected effects of lunar nonsphericity.

Nagler, R. G.

N01 PRELIMINARY ANALYSIS OF THE IMPORTANCE OF MATERIAL PROPERTIES AND THERMAL INPUTS ON HEAT SHIELDS FOR MARS ENTRY

Nagler, R. G.

Technical Report 32-940 (Unclassified)

(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 3, No. 5, May 1966, pp. 693-699)

The ranges of material properties potentially available for heat-shield systems entering the Martian atmosphere were evaluated as to the magnitudes of the effects of these individual properties on heat-shield thickness requirements and the coupling between these properties. Properties for a high-density, phenolic-nylon composite were used as a nominal case along with heat pulses derived from recent theoretical and experimental efforts. Each property (including heating data) was perturbed by an amount considered to be representative of potential improvements in heat-shield materials and technology. For the range of anticipated Mars entry environments included in this study, insulation appears to be more important than ablation. Uncertainties in radiant heating inputs had a greater effect on material-thickness requirements than uncertainties in convective heat inputs. The effect of individual internal properties, the surface properties, and the magnitudes of the heat inputs are coupled in manners not predictable from single-property perturbations. The thinness of the material required for Martian entry may cause fabrication considerations to have as much an effect on thickness selection as will heating or structural temperature constraints.

N02 THE THERMAL CONDUCTION PROCESS IN CARBONACEOUS CHARS

Nagler, R. G.

Technical Report 32-1010, February 1, 1967

(Unclassified)

Conductive heat transfer in porous carbonaceous chars has been considered in relation to the extent of char graphitization due to the time-temperature history of a particular degraded phenolic nylon sample. The available data on the conductance of phenolic nylon chars has been analyzed, and their practical value in application to entry or propulsion thermal protection systems has been estimated. Measured values of conductance appear conservative for atmospheric entry or one-start propulsion devices, but nonconservative for propulsion devices capable of several restarts. Chars can be tailored to produce the best attainable insulation capability or the strongest char, but not both. A compromise is necessary to combine both properties.

Nalbandian, A. J.

N03 A SENSITIVE S-BAND NOISE RECEIVER DEVELOPED FOR THE MARINER MARS 1964 SPACECRAFT PROGRAM

Keeler, L. H., Nalbandian, A. J., Olbeter, A. A.

Technical Report 32-1029, November 15, 1966

(Unclassified)

For abstract, see Keeler, L. H.

Neugebauer, M.

N04 AVERAGE PROPERTIES OF THE SOLAR WIND AS DETERMINED BY MARINER II

Neugebauer, M., Snyder, C. W.

Technical Report 32-991, November 1, 1966

(Unclassified)

This Report summarizes the properties of the positive-ion component of the solar wind observed during the 4 months of the *Mariner II* flyby mission to Venus in 1962. The proton average velocity and temperature were approximately 500 km/sec and 1.7×10^5 °K, respectively. Several streams of hot, high-velocity plasma were observed to recur at 27-day intervals, with peak velocity and temperature values of ~ 830 km/sec and 9×10^5 °K. One of these streams probably existed for at least 18 months. Between streams, the velocity dropped to a low of 307 km/sec, while the temperature was $\sim 3 \times 10^4$ °K. Near 1 AU, the average density was approximately 5 protons/cm³. The density was usually highest at the leading or western edge of each stream, with a maximum value of ~ 80 protons/cm³. Otherwise, the density varied inversely with the plasma velocity.

The ion velocity, temperature, and density were calculated from $\sim 35,000$ energy/charge spectra by fitting the data to isotropic Maxwell-Boltzmann distributions in a reference frame moving away from the Sun at the solar-wind velocity. A model in which the protons and alpha particles had equal thermal velocities gave a better fit to the observed spectra than a model having equal temperatures. The spectra usually had high-energy tails, which became more pronounced at the higher plasma velocities. The velocity, temperature, and high-energy tail were not strongly dependent on distance from the Sun, whereas the density varied approximately as the inverse square of this distance.

N05 MARINER II OBSERVATIONS OF THE SOLAR WIND II. RELATION OF PLASMA PROPERTIES TO THE MAGNETIC FIELD

Neugebauer, M., Snyder, C. W.

Technical Report 32-1107 (Unclassified)

(Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 7, April 1, 1967, pp. 1823-1828)

This Report summarizes some of the relations between the interplanetary magnetic field and the positive-ion component

of the solar wind as observed by *Mariner II*. Both the field strength and plasma density were generally much greater than normal at the leading edge of a long-lived high-velocity stream. For most of the period of observation, the ratio of magnetic energy density to the energy density of thermal motions of the positive ions was of the order of unity. The Alfvén velocity was usually in the range of 30–100 km/sec, and, during this period, the solar-wind flow past the Earth was always greater than the phase velocity of hydromagnetic waves, a necessary condition for the existence of a hydromagnetic bow shock. The *Mariner II* spectrometer, which always faced the Sun, measured the proton velocity dispersion, or temperature, along the solar radius vector. The dependence of this temperature on the instantaneous direction of the magnetic field was inconsistent with the condition $T_{\parallel} > T_{\perp}$ observed by the spherical plasma spectrometers on *Pioneer VI* and *Vela III*, unless the plasma was much hotter when the interplanetary field was perpendicular than when the field was parallel to the solar radius vector.

N06 MISSION TO A COMET: PRELIMINARY SCIENTIFIC OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Giffin, C. E., Neugebauer, M. M., Smith, E. J., Willingham, D. E.
Technical Memorandum 33-297, February 15, 1967
(Unclassified)

For abstract, see Brereton, R. G.

Newburn, R. L.

N07 MISSION TO A COMET: PRELIMINARY SCIENTIFIC OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Giffin, C. E., Neugebauer, M. M., Smith, E. J., Willingham, D. E.
Technical Memorandum 33-297, February 15, 1967
(Unclassified)

For abstract, see Brereton, R. G.

N08 VENUS/MERCURY SWINGBY WITH VENUS CAPSULE: PRELIMINARY SCIENCE OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Jr., McDonald, W. S., Barath, F. T., Herriman, A. G., Goforth, L.
Technical Memorandum 33-332, May 1, 1967 (Unclassified)

For abstract, see Brereton, R. G.

Newton, J. F., Jr.

N09 INITIAL PERFORMANCE OF A NEW NOZZLE GAS-DYNAMICS TEST FACILITY

Strand, L. D., Newton, J. F., Jr., Herrera, J. G.
Technical Memorandum 33-310, November 15, 1966
(Unclassified)

For abstract, see Strand, L. D.

Nielsen, T. H.

N10 SURFACE ADSORPTION IN MAGNESIUM OXIDE

Nielsen, T. H., Leipold, M. H.
Technical Report 32-949, June 1, 1966
(Unclassified)

Calculations are presented for approximating the adsorption energies of argon and helium atoms, and hydroxyl ions on magnesium oxide (MgO) surfaces, with consideration being given to abnormal, highly active sites. Results indicate extremely high (> 100 kcal/mole) adsorption energies for these species (in certain active sites) that are unlikely to be removed in thermal treatment. The number of such active sites is calculated, the ease of determination of impurities located in such active sites is evaluated, and methods of reducing such contamination by adsorption are discussed. Findings indicate that rearrangement of surface structure is unlikely in MgO and that adsorption of gas is the most likely mechanism by which MgO can lower its surface free energy.

Nixon, R. H.

N11 BIPOLAR ANALOG-TO-PULSE-WIDTH CONVERTER

Nixon, R. H.
Technical Report 32-1034, January 15, 1967
(Unclassified)

This Report describes the design and application of a bipolar analog-to-pulsewidth converter circuit module that was developed for the implementation of analog-to-digital conversions in spacecraft systems. The converter module, together with appropriate digital logic, has unique application in performing analog-to-digital conversions in environments where low-level measurements must be made in the presence of system noise. Sufficient electrical and mechanical design details are given to allow the fabrication of spacecraft-quality circuit modules. The design presented has been qualified for use on the *Mariner* spacecraft and on the *OGO-E* and *Bioscience* satellites.

Norton, R. H.

N12 PHOTOELECTRIC SPECTROPHOTOMETRY OF SELECTED SOUTHERN STARS

Aller, L. H., Faulkner, D. J., Norton, R. H.
Technical Report 32-942 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 144, No. 3, June 1966, pp. 1073–1100)

For abstract, see Aller, L. H.

Olbeter, A. A.

O01 A SENSITIVE S-BAND NOISE RECEIVER DEVELOPED FOR THE MARINER MARS 1964 SPACECRAFT PROGRAM

Keeler, L. H., Nalbandian, A. J., Olbeter, A. A.
Technical Report 32-1029, November 15, 1966
(Unclassified)

For abstract, see Keeler, L. H.

Onak, T.

- O02 THE NUCLEAR MAGNETIC RESONANCE AND MICROWAVE SPECTRA OF SOME DEUTERIO DERIVATIVES OF 2,4-DICARBACLOVOHEPTABORANE(7)**
Onak, T., Dunks, G. B., Beaudet, R. A., Poynter, R. L.
Technical Report 32-1038 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 88, No. 20, October 20, 1966, pp. 4622-4625)

Though the structure of 2,4-dicarbaclovoheptaborane(7) is known, ambiguous nuclear magnetic resonance (NMR) assignments were obtained for both the ^{11}B and ^1H NMR spectra of this molecule. Deuterium exchange was expected to aid in the NMR analysis. Although it exchanges completely at high temperatures, at lower temperatures deuterium exchanges in only three definite positions. A determination of these deuterium atom locations by microwave spectroscopy for the partially deuterated isotopic species allows an unequivocal assignment for both the ^{11}B and ^1H NMR spectra. For the partially deuterated molecule, the three deuterium atoms are preferentially substituted on the boron atoms in the base plane. These results are compatible with those for the NMR spectra of related boron compounds.

Otoshi, T. Y.

- O03 GROUND INSTRUMENTATION FOR MARINER IV OCCULTATION EXPERIMENT**
Levy, G. S., Otoshi, T. Y., Seidel, B. L.
Technical Report 32-984, September 15, 1966
(Unclassified)

For abstract, see Levy, G. S.

Patterson, J. H.

- P01 CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION**
Turkevich, A. L., Knolle, K., Franzgrote, E., Patterson, J. H.
Technical Report 32-1090 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 2, January 15, 1967, pp. 831-839)

For abstract, see Turkevich, A. L.

- P02 INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS**
Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A., Patterson, J. H., Franzgrote, E.
Technical Report 32-1065 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 12, December 1966, pp. 1681-1686)

For abstract, see Turkevich, A.

Peelgren, M. L.

- P03 LITHIUM-BOILING POTASSIUM TEST LOOP INTERIM REPORT**
Kikin, G. M., Davis, J. P., Griffin, D. C., Peelgren, M. L., Phillips, W. M.
Technical Report 32-1083, September 15, 1966
(Unclassified)

For abstract, see Kikin, G. M.

Perkins, G. S.

- P04 RANGER BLOCK III ATTITUDE CONTROL SYSTEM: MANUFACTURING, TESTING AND PERFORMANCE**
Almaguer, T. A., Jr., Baxter, T. G., Hand, P. J., Perkins, G. S., Summers, R. H.
Technical Report 32-915, September 15, 1966
(Unclassified)

For abstract, see Almaguer, T. A., Jr.

Perlman, M.

- P05 AN ALGORITHM FOR THE SYNTHESIS OF BINARY SEQUENCE DETECTORS**
Perlman, M.
Technical Report 32-1019, December 15, 1966
(Unclassified)

This Report presents an algorithm for synthesizing a sequential network to detect a given n -place binary sequence within a serialized binary data stream. Sequences are characterized as binary (n, r) ring sequences, and the state assignment is determined from the n r -bit subsequences. The results are compared with the implementation of a binary sequence detector made up of an $(n - 1)$ -stage shift register and an n -input decisional element.

Peyret, R.

- P06 TWO-DIMENSIONAL UNSTEADY FLOW IN A TRAVELING WAVE PLASMA ACCELERATOR**
Peyret, R.
Technical Report 32-1018, November 1, 1966
(Unclassified)

This Report presents a study of the two-dimensional unsteady flow in a traveling-wave plasma accelerator using the small-perturbation theory under the conditions of small magnetic Reynolds number and weak electromagnetic interaction. The partial differential equation which determines the pressure is solved by using a Laplace transform. The other quantities are deduced from the pressure by integration of rather simple equations. Then, the analytical results are numerically computed to clarify the effect of different parameters.

Phillips, W. M.

P07 EVALUATION OF OXIDATION-RESISTANT COATINGS FOR INERT-ATMOSPHERE APPLICATIONS

Phillips, W. M.

Technical Report 32-1014, January 15, 1967
(Unclassified)

A series of oxidation-resistant coatings was tested in argon containing traces of oxygen and water vapor at 2000°F for 500 hr. The coatings tested were tin-aluminum and modified silicides applied to a substrate of Cb-1 Zr and an unmodified silicide applied to a subcoating of molybdenum on Cb-1 Zr. The samples were evaluated by metallography, microhardness testing, bend testing, and microprobe analysis. The chromium-modified silicides offered little oxidation protection under these conditions and resulted in chromium diffusion into the substrate. The tin-aluminum coating produced adequate oxidation resistance despite spalling. The use of the unmodified silicide over a diffusion barrier of molybdenum appeared to be the most effective technique of protection.

P08 REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS VOLUME III. NUCLEAR FUELS

Phillips, W. M.

Technical Memorandum 33-262, October 15, 1965
(Secret)

The Memorandum, which is part of a three-part survey of industry-proposed in-pile thermionic reactor concepts, presents a summary of nuclear fuel and materials considerations. Only in-pile thermionic concepts for space-powerplant application are reviewed, comparing the flashlight, pancake, and externally fueled designs. Fuels proposed for these designs, as well as other possible fuels, are discussed.

P09 LITHIUM-BOILING POTASSIUM TEST LOOP INTERIM REPORT

Kikin, G. M., Davis, J. P., Griffin, D. C., Peelgren, M. L.,
Phillips, W. M.

Technical Report 32-1083, September 15, 1966
(Unclassified)

For abstract, see Kikin, G. M.

Pickering, W. H.

P10 NAVIGATING THE MARINER SPACECRAFT TO MARS

Pickering, W. H.

Technical Report 32-1032 (Unclassified)
(Reprinted from *Proceedings of the American Philosophical Society*, Vol. 110, No. 5, October 1966, pp. 332-339)

The flight of the *Mariner IV* spacecraft demonstrated that the problem of navigating across the solar system can be solved. Accurate launch trajectories can be attained, the path of the spacecraft can be precisely mapped, path correction maneuvers can be carried out, and mapping of the spacecraft motion in

the vicinity of the planet can be accomplished. To make the navigation still more precise, the next steps will be:

- (1) More accurate computation. At present, computational accuracy is not as good as the doppler observational accuracy.
- (2) Addition of direct range observations. Measurement of the actual distance to the spacecraft will add new data of high precision.
- (3) Addition of terminal guidance. For the highest accuracy at the planet, the spacecraft must make observations of the planet itself and adjust its path accordingly. Small residual errors in planet ephemerides or in trajectory observations and calculations will then be eliminated.

Pivrotto, T. J.

P11 RADIAL STATIC PRESSURE DISTRIBUTION IN CONFINED COMPRESSIBLE VORTEX FLOW FIELDS

Pivrotto, T. J.

Technical Report 32-1076, March 1, 1967
(Unclassified)

A confined vortex flow is studied to determine the effect of the fluid mass flow rate and the exit orifice diameter on the radial static-pressure distribution for a given vortex tube diameter, length, and injection configuration. A method is developed for determining the effective radial Reynolds number and effective exit hole radius from the experimentally determined maximum tangential Mach number and its radial location. Results show that the exit hole diameter had a significant effect on the radial pressure distribution, and that the mass flow rate lost its influence on the pressure distribution beyond a limiting value, which increased with increasing exit hole diameter. From 50 to 90% of the fluid momentum was lost at the cylindrical wall.

Porter, R. N.

P12 AN EXPERIMENTAL EVALUATION OF 100-lb-THRUST ABLATIVELY COOLED ROCKET ENGINES

Tyler, W. H., Porter, R. N.

Technical Report 32-978, October 1, 1966
(Unclassified)

For abstract, see Tyler, W. H.

P13 PROPELLANT EXPULSION IN UNMANNED SPACECRAFT

Porter, R. N., Stanford, H. B.

Technical Report 32-999, July 1, 1966
(Unclassified)

Bladders, diaphragms, and pistons can be used for the positive expulsion of earth-storable liquid rocket propellants in free-fall (zero-g). Work at JPL on these devices since the

1940's provided a technological background that aided in the development of reliable bladders for use in *Ranger* and *Mariner* spacecraft. Current advanced development programs are aimed at providing expulsion technology for future spacecraft.

P14 STORAGE TESTS OF NITROGEN TETROXIDE AND HYDRAZINE IN ALUMINUM CONTAINERS

Hollywood, L. P., Metz, T. R., Porter, R. N.
Technical Report 32-1039, January 15, 1967
(Unclassified)

For abstract, see Hollywood, L. P.

Posner, E. C.

P15 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.
Technical Report 32-772, Revision 1 (Unclassified)
(Reprinted from *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-3, No. 1, January 1967, pp. 57-65)

For abstract, see Anderson, T. O.

Poynter, R. L.

P16 THE NUCLEAR MAGNETIC RESONANCE AND MICROWAVE SPECTRA OF SOME DEUTERIO DERIVATIVES OF 2,4-DICARBACLOVOHEPTABORANE(7)

Onak, T., Dunks, G. B., Beaudet, R. A., Poynter, R. L.
Technical Report 32-1038 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 88, No. 20, October 20, 1966, pp. 4622-4625)

For abstract, see Onak, T.

Primack, J. R.

P17 ANALYSIS AND APPLICATION OF THE DIELECTRIC CONSTANT OF A TWO-TEMPERATURE PLASMA

Klevans, E. H., Primack, J. R.
Technical Report 32-888, June 15, 1966
(Unclassified)

For abstract, see Klevans, E. H.

Prislin, R. H.

P18 HIGH-AMPLITUDE DYNAMIC-STABILITY CHARACTERISTICS OF BLUNT 10-DEGREE CONES

Prislin, R. H.
Technical Report 32-1012, October 15, 1966
(Unclassified)

An extensive investigation of the dynamic-stability characteristics of a family of spherically blunted 10-deg cones was conducted in the JPL supersonic and hypersonic wind tunnels.

Two testing techniques were employed: the free-flight technique, and the captive free-oscillation technique. Parameters considered included center of rotation, oscillation amplitude, Mach number, and Reynolds number.

Several major trends were observed in the test results. For the very blunt shapes, dynamic stability was insensitive to changes in both oscillation amplitude and Mach number; however, for a sharp cone, a large change was evident for variations in both of these parameters. As the Mach number increased from low to high supersonic, the dynamic stability decreased. As the Mach number continued to increase into the hypersonic region, this trend reversed itself and the sharp cone became more stable. Variations in Reynolds number have a significant effect on dynamic-stability coefficients. The magnitude of this effect decreased with increasing model nose bluntness, oscillation amplitude, and Mach number. At the higher Mach numbers, correlation between results obtained with the alternate testing techniques was excellent. However, at the lower Mach numbers ($M = 2$), the agreement was less satisfactory, mainly because of scatter and poor quality of the captive data.

Randolph, J. E.

R01 MARINER MARS 1964 FLIGHT DYNAMIC DATA REVISION 1

Randolph, J. E.
Technical Memorandum 33-278, September 15, 1966
(Unclassified)

This Memorandum presents an analysis of the dynamic flight environment of the *Mariner Mars 1964* spacecraft. The reduced data from *Mariner III* and *Mariner IV* are presented and compared. Nine environmental measurements were taken for each spacecraft. These consisted of five vibration transducers within the payload area of each launch vehicle and four microphones mounted outside the vehicle on the launch complex umbilical tower. These telemetered and recorded data have been analyzed using the following techniques: oscillograms, bandpass, power spectra, shock spectra, and data compression. The reduced data are discussed with reference to each appropriate analysis technique. No comparison with ground test data is made.

Reid, M. S.

R02 PRECISION POWER MEASUREMENTS OF SPACECRAFT CW SIGNAL LEVEL WITH MICROWAVE NOISE STANDARDS

Stelzried, C. T., Reid, M. S.
Technical Report 32-1070 (Unclassified)
(Reprinted from *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-15, No. 4, December 1966, pp. 318-324)

For abstract, see Stelzried, C. T.

Rembaum, A.

- R03 HALL EFFECT IN POLY-*n*-VINYLCARBAZOLE-IODINE CHARGE-TRANSFER COMPLEX**
Hermann, A. M., Rembaum, A.
Technical Report 32-995 (Unclassified)
(Reprinted from *Journal of Applied Physics*, Vol. 37, No. 9, August 1966, pp. 3642-3643)

For abstract, see Herman, A. M.

- R04 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.**
I. ELECTRON TRANSFER FROM SODIUM TO POLY-4-VINYLBIPHENYL AND POLYVINYLNAPHTHALENES
Rembaum, A., Moacanin, J., Haack, R. F.
Technical Report 32-1054, Part I (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 4, October 1966, pp. 657-672)

The electron transfer from sodium to poly-4-vinylbiphenyl, poly-1-vinylnaphthalene, and poly-2-vinylnaphthalene results in polymer degradation, the rate of which depends on the structure of the unit segment. Spectroscopic and chemical evidence leads to the conclusion that during the chain-breaking process polymeric fragments are formed, which have the properties of "living polymers" and are capable of initiating the polymerization of a number of vinyl monomers. The postulated mechanism is consistent with the slow decrease in free-spin concentration, measured by means of the electron spin resonance technique, which also throws some light on electronic interactions in these polymers.

- R05 ANIONIC DEGRADATION OF VINYLAROMATIC POLYMERS.**
II. ELECTRON TRANSFER FROM SODIUM TO POLYACENAPHTHYLENE
Rembaum, A., Haack, R. F., Hermann, A. M.
Technical Report 32-1054, Part II (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 4, October 1966, pp. 673-691)

Electron transfer from sodium to high- or low-molecular-weight polyacenaphthylene results in instantaneous degradation. All the monomeric degradation products consisting of 1-hydroxy-acenaphthene, acenaphthene, and acenaphthylene were identified by spectroscopic methods. Under suitable experimental conditions acenaphthene was the only monomeric degradation product. A study of the degradation process as a function of sodium concentration, temperature, and amounts of monomer formed leads to the conclusion that at room temperature the drastic decrease in molecular weight is caused by a random chain scission accompanied by "unzipping," whereas at low temperature only chain scission occurred with no "unzipping." A tentative mechanism, accounting for most of the experimental facts, is presented.

Renzetti, N. A.

- R06 TRACKING AND DATA ACQUISITION FOR RANGER MISSIONS VI-IX**
Renzetti, N. A.
Technical Memorandum 33-275, September 15, 1966
(Unclassified)

This document summarizes the technical activities of the NASA/JPL Deep Space Network in support of Mission VI-IX of the *Ranger* Project. This work includes a synopsis of each mission, a comprehensive account of the tracking operations, and a brief evaluation of individual DSIF station performance. The tracking and data acquisition support provided by AFETR sites, Goddard Space Flight Center, and the Space Flight Operations Facility at the Jet Propulsion Laboratory are also delineated.

Rhein, R. A.

- R07 IGNITION AND COMBUSTION OF POWDERED METALS IN THE ATMOSPHERES OF VENUS, EARTH, AND MARS**
Rhein, R. A.
Technical Report 32-724 (Unclassified)
(Reprinted from *Astronautica Acta*, Vol. II, No. 5, 1965, pp. 322-327)

The ignition temperatures of a number of powdered metals have been measured in air, in a simulated Venus atmosphere (consisting, by volume, of 4.10% argon, 9.17% nitrogen, and the remainder carbon dioxide), and in a simulated Mars atmosphere (consisting, by volume, of 2.16% argon, 11.21% carbon dioxide, and the remainder nitrogen). This study was conducted to show that the atmospheres of the planets Mars and Venus could be utilized as chemical energy sources. Typical ignition temperatures of the following powdered metals were observed in the simulated Mars atmosphere: lithium, 405°C; beryllium, 762°C; calcium, 163°C; boron, 1203°C; cerium, 199°C; titanium, 916°C; zirconium, 614°C; thorium, 587°C; and uranium, 168°C. In the simulated Venus atmosphere, the following typical ignition temperatures were noted: lithium, 367°C; beryllium, earth ambient temperatures; magnesium, 676°C; calcium, 269°C; boron 1000°C; aluminum, 705°C; cerium, 147°C; titanium, 708°C; zirconium, 152°C; thorium, 627°C; and uranium, 134°C. It was found that, generally, the powdered metals ignited more readily in air than in the Venus atmosphere, and more readily in the Venus atmosphere than in the Mars atmosphere. These ignition temperatures were compared to those in atmospheres of pure nitrogen and pure carbon dioxide. The performance of these propellants was discussed, and it was concluded that boron and beryllium are the preferred fuels.

- R08 THE UTILIZATION OF POWDERED METALS AS FUELS IN THE ATMOSPHERES OF VENUS, EARTH, AND MARS**
Rhein, R. A.
Technical Report 32-1073, February 28, 1967
(Unclassified)

The ignition temperatures of a number of powdered metals were measured in air, in a simulated Venus atmosphere, and in a simulated Mars atmosphere. Each atmosphere was thought to consist of mixtures of argon, carbon dioxide, and nitrogen. This study was conducted to show that the atmospheres of the planets Mars and Venus might be utilized as sources of oxidizers for chemical energy. The heat liberated from the combustion of lithium, beryllium, and boron in the simulated Venus and Mars atmospheres was calculated from the compositions of the products formed. The product compositions were determined by chemical analysis.

Riebling, R. W.

R09 THE FORMATION AND PROPERTIES OF LIQUID SHEETS SUITABLE FOR USE IN ROCKET ENGINE INJECTORS

Riebling, R. W.

Technical Report 32-1112, June 15, 1967

(Unclassified)

An applied research program was conducted to determine the properties of sheets formed by a jet of liquid from a circular orifice directed tangentially against a concave cylindrical surface, as well as the conditions necessary to the formation of suitable sheets. Sheet dimensions and spatial orientation, and the distributions of mass and velocity across the flowing sheets, were measured, using three inert propellant simulants. All of these sheet parameters were correlated in terms of the geometry of the sheet formation devices. Injection velocity, propellant physical properties, and the absolute sizes of these devices were found to exert only second-order effects. Distributions of thickness and momentum flux were also obtained and correlated. All sheet properties were found to be scalable because of geometric and dynamic similarity, and can now be predicted and controlled with a high degree of confidence.

Roschke, E. J.

R10 EXPERIMENTAL INVESTIGATION OF A CONFINED, JET-DRIVEN WATER VORTEX

Roschke, E. J.

Technical Report 32-982, October 1, 1966

(Unclassified)

This Report deals with some of the effects on a confined, vortex flow produced by varying the aspect ratio. Investigation of a vortex flow of water within a right, circular cylinder, having a single, circular exit-hole centrally located in one end wall was accomplished primarily by means of static pressure measurements made on the closed end-wall. This vortex tube had a fixed diameter D , but a variable length L , such that aspect ratio variations in the range $0 < L/D < 12$ were obtainable. Experiments were conducted in the radial Reynolds number range $40 < Re_r < 1100$, using several exit-hole diameters of different size. Radial distributions of static pressure measured at the closed end-wall are presented for a variety of conditions in such a way as to bring out the effects of L/D while holding other parameters fixed. Tangential velocity dis-

tributions and angular momentum distributions were obtained by graphical differentiation of the static pressure distributions. Typical values of the jet recovery factor, the tangential Reynolds number, and the cylindrical-wall skin friction coefficient were inferred from pressure data. Because of the limited accuracy of the data, it was possible to establish only trends, but they are sufficiently well-determined as to show clearly the importance of aspect ratio on vortex flows of this type. One significant effect produced by an increasing L/D is a corresponding reduction in the size of the vortex core. It appears that increases in aspect ratio to increasingly larger values would have the adverse effect of producing vortices of decreasing strength, if the pressure at the cylindrical wall were held fixed. This possibility would impose severe restrictions on performance of multiple vortex-tube gas-core reactors that rely on diffusion-controlled nuclear-fuel containment and require vortex flows of high strength.

R11 FLOW-VISUALIZATION STUDIES OF A CONFINED, JET-DRIVEN WATER VORTEX

Roschke, E. J.

Technical Report 32-1004, September 15, 1966

(Unclassified)

This Report presents and discusses the results of visual observations of the flow of water within a confined, jet-driven vortex tube. This vortex tube had a fixed nominal diameter of 4 in., but was of variable length so effects produced by changes in aspect ratio could be studied. The basic configuration, having planar endwalls and a single exit hole, was modified by changing the shape of the endwalls and/or installing exit holes at both ends. Conical, hemispherical, and canted endwalls were investigated. The results of other experiments, such as injection of a second, heavier-than-water fluid; the insertion of probes into the flow; and the transient effects of changes in mass rate of flow supply, are also discussed. It is demonstrated that aspect ratio has a strong influence on the secondary flows in a confined vortex. The principal results are given in the form of color photographs typical of several flow conditions.

Rosen, R.

R12 A STUDY OF SECONDARY INJECTION OF GASES INTO A SUPERSONIC FLOW

Spaid, F. W., Zukoski, E. E., Rosen, R.

Technical Report 32-834, August 1, 1966

(Unclassified)

For abstract, see Spaid, F. W.

Ross, R. G., Jr.

R13 THE DESIGN AND TESTING OF AN INFLATED SPHERE IMPACT LIMITER

Ross, R. G., Jr., Layman, W. E.

Technical Report 32-1037, December 15, 1966

(Unclassified)

An inflated-sphere landing vehicle is analyzed in terms of structural requirements and geometric configurations necessary

to effect maximum utilization of the vehicle's energy-absorbing properties. The requirements for an optimum limiter and all important derivations are included. Fabrication techniques developed during the construction of a prototype vehicle are discussed, and specific recommendations are made for future fabrication. The preliminary test results presented were obtained by shooting a 5-ft-diameter prototype impact limiter against a flat surface at velocities of 100 and 165 ft/sec. Impact testing was conducted in a large vacuum chamber fitted with a launching mechanism designed for the prototype impact limiter.

Rupe, J. H.

- R14 AN EXPERIMENTAL CORRELATION OF THE NONREACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE. PART II. INSTRUMENTATION, EXPERIMENTAL APPARATUS, AND EXPERIMENTAL TECHNIQUES**
Clayton, R. M., Rupe, J. H., Gerbracht, F. G.
Technical Report 32-255, May 15, 1967 (Unclassified)

For abstract, see Clayton, R. M.

Rusch, W. V. T.

- R15 EDGE DIFFRACTION FROM TRUNCATED PARABOLOIDS AND HYPERBOLOIDS**
Rusch, W. V. T.
Technical Report 32-1113, June 1, 1967
(Unclassified)

The geometrical theory of edge diffraction is applied to the problem of scattering from both paraboloidal and hyperboloidal reflectors. The results are compared with classical results from geometrical optics and vector diffraction theory. It is found that the edge-diffracted field provides an excellent approximation to the rigorously-determined field except in certain regions such as shadow-light boundaries.

Russell, D. A.

- R16 SHOCK-WAVE STRENGTHENING BY AREA CONVERGENCE**
Russell, D. A.
Technical Report 32-1067 (Unclassified)
(Reprinted from *Journal of Fluid Mechanics*, Vol. 27, Part 2, 1967, pp. 305-314)

A 17-in. diameter shock tube was coupled to a 1-in. tube by a 10-deg half-angle conical convergence. Timing measurements showed that the shock waves emerged from the convergence at 2-3 times their entrance speeds, and then decelerated downstream. After the application of a viscous correction, the shock speeds at the convergence exit agreed to within 5% with equilibrium real-gas calculations of the model of Chester (1954), Chisnell (1957), and Whitham (1958). The downstream deceleration, due to viscosity and to higher-order interactions not included in the theory, was also briefly studied.

San Miguel, A.

- S01 SOME EXPERIMENTAL OBSERVATIONS ON THE STORED ENERGY FUNCTION FOR SMALL VALUES OF STRAIN INVARIANTS**
San Miguel, A., Landel, R. F.
Technical Report 32-1006 (Unclassified)
(Reprinted from *Transactions of the Society of Rheology*, Vol. 10, No. 1, 1966, pp. 369-383)

To evaluate the stored energy function W for elastomeric materials, at least biaxial experiments must be made. Two biaxial testers developed at JPL are an inflated cylinder device and a biaxial sheet tester. Some preliminary experimental results obtained with these two devices at small values of strain invariants are presented for a polyurethane elastomer. These results are analyzed without making the assumption that the elastomer is incompressible, a fact which modifies the analysis of multiaxial or large-strain behavior. The results from the biaxial sheet tester are consistent with those obtained from an inflated cylinder of the same material, though experimental difficulties prevent a detailed comparison. Nevertheless, both series of experiments show that all three terms of $\partial W / \partial I_i$ depend strongly on the invariants I_i . Moreover, $\partial W / \partial I_2$ is negative, in agreement with theoretical expectations. Thus, the form of W in the region where $I_i < 4$ is very complex.

Schaper, P. W.

- S02 BALLOON OBSERVATIONS OF THE RADIANCE OF THE EARTH BETWEEN 2100 cm^{-1} AND 2700 cm^{-1}**
Shaw, J. H., McClatchey, R. A., Schaper, P. W.
Technical Report 32-1080 (Unclassified)
(Reprinted from *Applied Optics*, Vol. 6, No. 2, February 1967, p. 227)

For abstract, see Shaw, J. H.

- S03 HIGH-DISPERSION SPECTROSCOPIC OBSERVATIONS OF MARS. II. THE WATER-VAPOR VARIATIONS**
Schorn, R. A., Spinrad, H., Moore, R. C., Smith, H. J., Giver, L. P.
Technical Report 32-1048 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 2, February 1967, pp. 743-752)

Nineteen high-dispersion spectrograms of Mars taken at McDonald and Lick Observatories during the 1964-1965 apparition have been examined for Doppler-shifted rotational lines of H_2O near $\lambda 8200$. The presence of H_2O in the atmosphere of Mars appears to be confirmed, but indications are that its concentration varies with time and location on the planet. Typical amounts of H_2O are of the order of 10-20 μ precipitable water vapor.

The spectroscopic results are compared with photographic patrol studies during this apparition. The amount of water in the vapor phase seems to depend upon the size of the Martian polar cap, implying a physical connection between the two.

Schmuecker, J. D.

- S04 MARINER MARS 1964 BASIC STRUCTURE, DESIGN AND DEVELOPMENT**
Schmuecker, J. D., Spehalski, R. J.
Technical Report 32-953, May 1, 1967
(Unclassified)

This Report summarizes the design and development of the *Mariner* Mars 1964 spacecraft basic structure. Specific design considerations and the evolution of the structural design are discussed. The detail design is described, and the fabrication, assembly, and quality control procedures are presented. Finally, conclusions and recommendations are given that may be of value in structural design for future projects.

Schneider, H. W.

- S05 CONSIDERATIONS REGARDING THE PNEUMATIC TREATMENT OF VOYAGER SHROUD STRUCTURES**
Schneider, H. W.
Technical Memorandum 33-295, April 15, 1967
(Unclassified)

Typically *Voyager*-related aspects are discussed for pneumatic treatment of the enshrouded spacecraft during final assembly, transport, and prelaunch operations. Indications are that conventional pneumatic operations, such as pressurization and purging, can be done with existing basic equipment. However, much more system capability than exists at present will be required where volume and flow rates are concerned. Procedural changes and minor system modifications will be necessary to satisfy the prime ground rule that all pneumatic operations have to be done at elevated pressures. Since a terminal gas decontamination of the large (up to 19-ft-diameter) *Voyager* spacecraft and shroud cavities represents engineering problems whose solution will require some development efforts, it is recommended that a detailed engineering study of this particular area be conducted as early in the program as possible.

Schorn, R. A.

- S06 HIGH-DISPERSION SPECTROSCOPIC OBSERVATION OF MARS. I. THE CO₂ CONTENT AND SURFACE PRESSURE**
Spinrad, H., Schorn, R. A., Moore, R., Giver, L. P., Smith, H. J.
Technical Report 32-1048 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 146, No. 2, November 1966, pp. 331-338)

For abstract, see Spinrad, H.

Schutz, F. L., et al.

- S07 MARINER MARS SCIENCE SUBSYSTEM**
Schutz, F. L., et al.
Technical Report 32-813, August 15, 1966
(Unclassified)

This Report is a series of twelve papers relating to various aspects of the *Mariner* Mars 1964 science subsystem. These papers were presented in August 1965 at the WESCON (Western Electronic Show and Convention) meeting in Los Angeles, California.

Scott, R. F.

- S08 LUNAR SURFACE STRENGTH: IMPLICATIONS OF LUNA 9 LANDING**
Jaffe, L. D., Scott, R. F.
Technical Report 32-1003 (Unclassified)
(Reprinted from *Science*, Vol. 153, No. 3734, July 22, 1966, pp. 407-408)

For abstract, see Jaffe, L. D.

Scully, J. R.

- S09 GUIDANCE AND CONTROL OF THE MARINER PLANETARY SPACECRAFT**
Scully, J. R.
Technical Report 32-924 (Unclassified)
(Reprinted from *Peaceful Uses of Automation in Outer Space*, Plenum Press, 1966, pp. 97-108)

The unmanned exploration of the Moon and nearby planets imposes very significant requirements on the guidance and control system of both the booster rocket and the spacecraft. The booster rocket must be launched into a narrow, moving corridor with great precision within a limited period of time. After separation, the spacecraft must be capable of providing corrections to the trajectory and controlling the orientation of solar panels, antennas, and scientific instruments.

The guidance and control systems of the *Mariner* planetary spacecraft are described. Some of the techniques developed to provide redundant operation during the long interplanetary flight are discussed. Flight performance of the *Mariner* guidance and control systems is reported.

Seidel, B. L.

- S10 GROUND INSTRUMENTATION FOR MARINER IV OCCULTATION EXPERIMENT**
Levy, G. S., Otoshi, T. Y., Seidel, B. L.
Technical Report 32-984, September 15, 1966
(Unclassified)

For abstract, see Levy, G. S.

Selzer, R. H.

- S11 DIGITAL COMPUTER PROCESSING OF X-RAY PHOTOGRAPHS**
Selzer, R. H.
Technical Report 32-1028, November 15, 1966
(Unclassified)

The interpretation of medical and biological pictures, such as X-ray photographs, can frequently be made easier if selected portions of the image are first enhanced by means of a digital

computer. Two particular enhancement methods are described in this Report: The first uses image subtraction to achieve enhancement by removing unimportant information from the picture; the second uses two-dimensional filtering to achieve enhancement by emphasizing selected portions of the picture frequency spectrum. The latter method is particularly useful for bringing out fine detail that is totally invisible on the unprocessed picture. Examples of enhanced medical X-rays, photomicrographs, and infrared photographs are shown.

Selwitz, L.

**S12 RTG INTEGRATION PROBLEM AREAS
AND PARAMETRIC ANALYSIS**

Selwitz, L.

Technical Memorandum 33-321, February 1, 1967

(Unclassified)

Current radioisotope thermoelectric generator (RTG) design concepts for space power systems generally lack understanding of, or regard for, the total mission and spacecraft requirements, and are usually unsupported by sufficient reliable data or technical information. Too little differentiation is made between proof-of-principle hardware concepts and mission applications. In the former, flights of specific RTGs or families of RTGs are planned for the purpose of determining the feasibility of new RTG sizes, weights, and fuels; in the latter, the RTG has functional importance, utilized as a component whose sole purpose is to support the primary goals of the mission.

Shaw, J. H.

**S13 BALLOON OBSERVATIONS OF THE RADIANCE OF
THE EARTH BETWEEN 2100 cm^{-1} AND 2700 cm^{-1}**

Shaw, J. H., McClatchey, R. A., Schaper, P. W.

Technical Report 32-1080 (Unclassified)

(Reprinted from *Applied Optics*, Vol. 6, No. 2,
February 1967, p. 227)

A grating spectrometer capable of measuring small radiation fluxes with a spectral resolution of 95 at 4.3μ is described. Bands of CO_2 , N_2O , and O_3 are identified in spectra between 2100 and 2700 cm^{-1} of the earth and lower atmosphere obtained from an altitude of 30 km with this instrument. Scattering of solar radiation by clouds was observed between 2400 and 2700 cm^{-1} . A temperature profile of the atmosphere to 30 km determined from an analysis of the measurements in the region of the $4.3\text{-}\mu$ CO_2 band is compared with radiosonde observations made during the flight.

Shimada, K.

**S14 THEORY OF THERMIONIC ENERGY CONVERSION.
PART I: SURFACE PHYSICS**

Shimada, K.

Technical Memorandum 33-313, January 1, 1967-

(Unclassified)

The number of electrons and ions thermionically emitted at a certain surface temperature of metal (temperature-saturated emission) has great importance, since the operation of a thermionic energy converter is based upon the collection of this emission. The emission surface (emitter) is heated by primary energy sources, such as the Sun, a nuclear reactor or radioisotope decay. Surface physics theory describing the saturated electron, ion, and atom emission from bare-metal and cesiated-metal surfaces is described in this Memorandum. Other theories describing the characteristics of thermionic energy converters will be reviewed in two subsequent Memoranda.

Simha, R.

**S15 NON-RANDOMNESS IN BASE SEQUENCES
OF DNAs**

Moacanin, J., Simha, R.

Technical Report 32-972 (Unclassified)

(Reprinted from *Biochemical and Biophysical Research Communications*, Vol. 23, No. 5, 1966, pp. 592-599)

For abstract, see Moacanin, J.

**S16 SOME CONSEQUENCES OF THE GIBBS-DIMARZIO
THEORY OF THE GLASS TRANSITION**

Moacanin, J., Simha, R.

Technical Report 32-992 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*,
Vol. 45, No. 3, August 1966, pp. 964-967)

For abstract, see Moacanin, J.

Sjogren, W. L.

**S17 PHYSICAL CONSTANTS AS DETERMINED FROM
RADIO TRACKING OF THE RANGER
LUNAR PROBES**

Sjogren, W. L., Trask, D. W., Vegos, C. J.,

Wollenhaupt, W. R.

Technical Report 32-1057, December 30, 1966

(Unclassified)

Estimates of the gravitational mass of the Earth and Moon, the tracking-station locations, and the lunar radii at the various impact points are derived from the reduction of Earth-based radio-tracking data obtained during the *Ranger* lunar missions. The estimates are consistent and compare favorably with results from other work. The method of analysis, the theoretical model used, the estimator, the data quality and quantity, and the data fit are discussed, as well as projected improvements for follow-on analysis.

**S18 LUNAR ORBITER RANGING DATA:
INITIAL RESULTS**

Mulholland, J. D., Sjogren, W. L.

Technical Report 32-1087 (Unclassified)

(Reprinted from *Science*, Vol. 155, No. 3758,
January 6, 1967, pp. 74-76)

For abstract, see Mulholland, J. D.

- S19 COMPRESSED TRACKING DATA USED FOR FIRST ITERATION IN SELENODESY EXPERIMENT, LUNAR ORBITER I AND II**
Lorell, J., Sjogren, W. L., Boggs, D.
Technical Memorandum 33-343, May 1, 1967
(Unclassified)

For abstract, see Lorell, J.

Sloan, R. K.

- S20 THE SCIENTIFIC EXPERIMENTS OF MARINER IV**
Sloan, R. K.
Technical Report 32-958 (Unclassified)
(Reprinted from *Scientific American*, Vol. 214, No. 5, May 1966, pp. 62-72)

This Report concludes a series of three articles on the highly successful voyage of the spacecraft *Mariner IV*. Its instruments not only provided new information on Mars but also monitored fields and particles in planetary space.

Smith, E. J.

- S21 A REVIEW OF LUNAR AND PLANETARY MAGNETIC FIELD MEASUREMENTS USING SPACE PROBES**
Smith, E. J.
Technical Report 32-1059 (Unclassified)
(Reprinted from *Magnetism and the Cosmos*, contributions to NATO Advanced Study Institute on Planetary and Stellar Magnetism held in 1965 at the School of Physics, the University, Newcastle-upon-Thyne, published by Oliver and Boyd Ltd., Edinburgh, 1967, pp. 271-287)

Lunar and planetary magnetic field measurements obtained during the *Pioneer I*, *Lunik II*, *Mariner II*, and *Mariner IV* space probes are reviewed. The spacecraft trajectory and even some of the instrument characteristics are considered. Interpretation of the data is made by using the methods of plasma physics as well as the results of magnetic measurements obtained near the earth. The restricted objective of the review is to estimate the planetary dipole moment by using the knowledge of how far certain effects of the geomagnetic field extend into interplanetary space.

- S22 MISSION TO A COMET: PRELIMINARY SCIENTIFIC OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES**
Brereton, R. G., Newburn, R. L., Giffin, C. E., Neugebauer, M. M., Smith, E. J., Willingham, D. E.
Technical Memorandum 33-297, February 15, 1967
(Unclassified)

For abstract, see Brereton, R. G.

Smith, H. J.

- S23 HIGH-DISPERSION SPECTROSCOPIC OBSERVATION OF MARS. I. THE CO₂ CONTENT AND SURFACE PRESSURE**
Spinrad, H., Schorn, R. A., Moore, R., Giver, L. P., Smith, H. J.
Technical Report 32-1048 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 146, No. 2, November 1966, pp. 331-338)

For abstract, see Spinrad, H.

- S24 HIGH-DISPERSION SPECTROSCOPIC OBSERVATIONS OF MARS. II. THE WATER-VAPOR VARIATIONS**
Schorn, R. A., Spinrad, H., Moore, R. C., Smith, H. J., Giver, L. P.
Technical Report 32-1048 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 2, February 1967, pp. 743-752)

For abstract, see Schorn, R. A.

Smyth, H. T.

- S25 A STUDY OF THE STRUCTURE OF GRAIN BOUNDARIES IN POLYCRYSTALLINE MAGNESIUM OXIDE**
Smyth, H. T., Leipold, M. H.
Technical Report 32-1042, April 15, 1967
(Unclassified)

The structure of the grain boundary in a typical polycrystalline ceramic (MgO) is described in terms of a random network. The development is based on the existence of variable coordination of both species in the structure to permit a stable random network. The theory first develops the energy relationship and coordination distribution in such a network in a stress-free homogeneous environment and then considers the distribution that might exist in a gradient occurring at a discontinuity (grain boundary or free surface).

The results suggest that such an approach is capable of describing the conditions at disordered regions in an ordered structure. The theory indicates that in a theoretically pure MgO, the thickness of the random network at a free surface would be of the order of 2-3 atomic distances, and the total thickness of a grain boundary, of the same order of magnitude.

Snyder, C. W.

- S26 AVERAGE PROPERTIES OF THE SOLAR WIND AS DETERMINED BY MARINER II**
Neugebauer, M., Snyder, C. W.
Technical Report 32-991, November 1, 1966
(Unclassified)

For abstract, see Neugebauer, M.

- S27 MARINER II OBSERVATIONS OF THE SOLAR WIND.**
II. RELATION OF PLASMA PROPERTIES TO THE MAGNETIC FIELD
 Neugebauer, M., Snyder, C. W.
 Technical Report 32-1107 (Unclassified)
 (Reprinted from *Journal of Geophysical Research*, Vol. 72, No. 7, April 1, 1967, pp. 1823-1828)

For abstract, see Neugebauer, M.

Snyder, D. C.

- S28 SHOCK-SPECTRUM ANALYSIS PROGRAM**
 Snyder, D. C., Wiksten, D. B.
 Technical Memorandum 33-326, March 1, 1967
 (Unclassified)

The shock-spectrum analysis program for the 7094 computer computes the primary and residual shock spectra of a digital signal by the recursive filtering method. The program also automatically plots selected output on the SC-4020 plotter and punches the data on cards for additional analysis. The program is written in FORTRAN IV and MAP language.

Spaid, F. W.

- S29 A STUDY OF SECONDARY INJECTION OF GASES INTO A SUPERSONIC FLOW**
 Spaid, F. W., Zukoski, E. E., Rosen, R.
 Technical Report 32-834, August 1, 1966
 (Unclassified)

The flow field around the injection port for secondary injection of a gas normal to a supersonic stream has been studied in a series of wind-tunnel experiments. The experiments were conducted at free-stream Mach numbers of 1.38 to 4.54. Gaseous nitrogen, argon, and helium were injected through a circular hole and sonic flow was maintained at the injection orifice. Data presented include static-pressure distributions on the wall in the region of the injector, shock shapes, and injectant-mass-fraction, total-pressure, and velocity profiles downstream of the injector. A scale parameter has been calculated, based on a simple, inviscid model of the flow field. This scale parameter gives a good general correlation of the data. Use of this scale parameter allows the prediction of a simple scaling law for the normal forces on a wall produced by secondary injection, which is in approximate agreement with existing rocket-motor test results.

Spehalski, R. J.

- S30 MARINER MARS 1964 MECHANICAL CONFIGURATION**
 Spehalski, R. J.
 Technical Report 32-933, September 1, 1966
 (Unclassified)

This Report summarizes the design considerations for the mechanical configuration of the *Mariner* Mars 1964 spacecraft. Sources of various configuration design requirements are discussed, including the launch vehicle and the spacecraft system and its subsystems. The evolution of the design, representative problems encountered during the configuration evolution, and criteria used in evaluation of succeeding iterations — satisfaction of subsystem requirements, structural efficiency, operational simplicity, and growth potential — are presented. The resultant design is described and evaluated relative to the proposed criteria. Finally, conclusions and recommendations are given that may be of value in mechanical configuration design for future projects.

- S31 MARINER MARS 1964 BASIC STRUCTURE, DESIGN AND DEVELOPMENT**
 Schmuecker, J. D., Spehalski, R. J.
 Technical Report 32-953, May 1, 1967
 (Unclassified)

For abstract, see Schmuecker, J. D.

- S32 MARINER IV MECHANICAL OPERATIONS**
 Spehalski, R. J.
 Technical Report 32-954, December 1, 1966
 (Unclassified)

This Report summarizes the salient features of spacecraft mechanical operations based on experience with the *Mariner IV* spacecraft. The scope of these operations is presented through photographs of various flight and test configurations. Particular operational aspects, including assembly problems, flight preparation, personnel, and documentation, are discussed. General conclusions are drawn that may be of value in future space projects.

Spinrad, H.

- S33 HIGH-DISPERSION SPECTROSCOPIC OBSERVATION OF MARS.**
I. THE CO₂ CONTENT AND SURFACE PRESSURE
 Spinrad, H., Schorn, R. A., Moore, R., Giver, L. P., Smith, H. J.
 Technical Report 32-1048 (Unclassified)
 (Reprinted from *The Astrophysical Journal*, Vol. 146, No. 2, November 1966, pp. 331-338)

From high-dispersion infrared McDonald and Lick Observatories' spectograms of the planet, the carbon-dioxide abundance of Mars has been determined to be 90 ± 27 m-atm (standard temperature and pressure) at 200°K, chosen as a representative lower atmosphere temperature. The weak $5\nu_3$ carbon-dioxide lines near $\lambda = 8700$ Å were used. An abundance of 90 m-atm of carbon dioxide gives a surface *partial* pressure of 6.6 mbar. The observation and reductions used in these determinations are discussed in this Report.

By comparing the weak-line carbon-dioxide abundance with Sinton's and Kuiper's measures of the saturated 1.6- and 2.0- μ

bands, the total surface pressure was found to be 8 ± 4 mbar from the $1.6\text{-}\mu$ band and 16 ± 8 mbar from the $2.0\text{-}\mu$ band. The technique of analysis followed that of Kaplan, Münch, and Spinrad, as well as Owen and Kuiper. The lower pressure value ($1.6\text{-}\mu$ data) is preferred. A compromise value for the total surface pressure is 10^{+10}_{-5} mbar. This result was compared to the *Mariner IV* occultation data, which yield a total surface pressure of 5 or 6 mbar if the temperature of the lower Martian atmosphere is 180°K . The difference in surface pressure values is not substantial; the occultation results coupled with the carbon-dioxide abundance discussed in this Report suggest an almost pure carbon-dioxide atmosphere for Mars.

S34 HIGH-DISPERSION SPECTROSCOPIC OBSERVATIONS OF MARS

II. THE WATER-VAPOR VARIATIONS

Schorn, R. A., Spinrad, H., Moore, R. C., Smith, H. J., Giver, L. P.

Technical Report 32-1048 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 147, No. 2, pp. 318-324)

For abstract, see Schorn, R. A.

Stanford, H. B.

S35 PROPELLANT EXPULSION IN UNMANNED SPACECRAFT

Porter, R. N., Stanford, H. B.

Technical Report 32-899, July 1, 1966 (Unclassified)

For abstract, see Porter, R. N.

Stanley, R.

S36 ALGORITHMIC COMPLEXITY

Stanley, R.

Technical Report 32-999, September 1, 1966 (Unclassified)

The concept of algorithmic complexity that was introduced by Kolmogorov and expanded by Ofman provides a quantitative means of measuring the complexity of computing a discrete function — a function with finite domain and range. To be precise in the work reported here, it is assumed that the computation is done by a special type of finite-state machine, a (p, q) automaton. After reviewing the definitions in the field of algorithmic complexity, estimates are made for the maximum possible algorithmic complexity of a discrete function that can be computed on the simplest possible (p, q) automaton, a $(2, 2)$; this allows comparison of the algorithmic complexities relative to (p, q) automata and those relative to $(2, 2)$ automata. Next, bounds are obtained on the complexity of matrix multiplication. Finally, algorithmic complexity is re-

lated to the theory of permutation groups on the domain and range of a function, and various criteria are discussed for ensuring a function's having relatively low complexity.

Stelzried, C. T.

S37 PRECISION POWER MEASUREMENTS OF SPACECRAFT CW SIGNAL LEVEL WITH MICROWAVE NOISE STANDARDS

Stelzried, C. T., Reid, M. S.

Technical Report 32-1070 (Unclassified)

(Reprinted from *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-15, No. 4, December 1966, pp. 318-324)

One of the important measurements required in the evaluation of a spacecraft communications system is the determination of the absolute level of the received CW power. A new, precise measurement method which compares CW signal power with microwave noise power is described. This technique, together with statistical methods of data reduction, results in significantly increased accuracy. Application of this technique to the *Mariner IV* spacecraft was begun on June 29, 1965, and continued after Mars encounter. The theory, equipment, and method of data acquisition and reduction are described. Results and accuracies are discussed. The *Mariner IV* spacecraft received power at Mars encounter normalized for 100 percent antenna efficiency was measured to be -154.2 dBm as compared to a theoretically predicated level of -153.1 dBm.

Strand, L. D.

S38 INITIAL PERFORMANCE OF A NEW NOZZLE GAS-DYNAMICS TEST FACILITY

Strand, L. D., Newton, J. F., Jr., Herrera, J. G.

Technical Memorandum 33-310, November 15, 1966 (Unclassified)

A general description is given of a newly developed gas-flow test facility and its characteristics. A cold-flow facility is compared to actual motor firings for preliminary rocket-nozzle gas-dynamics testing. The differences in the flow conditions within this system and an actual motor-firing nozzle and the causes of these differences are discussed, as are other types of nozzle gas-dynamics experiments to which this facility is readily applicable. The test nozzles, instrumentation, and test procedure used in the initial test program, as well as facility performance and test results, are also described.

S39 RECENT MEASUREMENTS AT JPL OF PARTICLE SIZE OF Al_2O_3 FROM SMALL ROCKET MOTORS

Dobbins, R. A., Strand, L. D.

Technical Memorandum 33-352, June 15, 1967 (Unclassified)

For abstract, see Dobbins, R. A.

Sturms, F. M., Jr.

S40 TRAJECTORY ANALYSIS OF A 1970 MISSION TO MERCURY VIA A CLOSE ENCOUNTER WITH VENUS

Sturms, F. M., Jr., Cutting, E.

Technical Report 32-943 (Unclassified)

(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 3, No. 5, May 1966, pp. 624-631)

This paper gives the results of a preliminary study of trajectory and guidance considerations for a close flyby of the planet Mercury by an unmanned spacecraft. The mission utilizes a trajectory having a close encounter with Venus enroute to Mercury and requires no powered flight after Earth injection except for guidance corrections. By using conic and integrated trajectories, a mission design has been obtained which gives a launch period of 30 days extending from July 28 to August 27, 1970. The total flight times range from 158 to 182 days, with Mercury encounter near the end of January 1971. The launch period results from design constraints of a maximum launch vis-viva energy (C_3) of $14 \text{ km}^2/\text{sec}^2$ and a constant Venus encounter date of November 26, 1970. The maximum launch energy for the mission is only 30% of the minimum energy for a direct Mercury trajectory (about $47 \text{ km}^2/\text{sec}^2$) and allows significant payloads to be delivered by an *Atlas-Centaur* boost vehicle. The mission can be accomplished with existing Earth-based radio guidance only, using three midcourse corrections at points about 6 days after injection, about 6 days prior to Venus encounter, and about 8 days after Venus encounter. For each maneuver, the rms velocity requirements, orbit-determination error, and execution error are obtained. The mean total requirement for all three maneuvers is about 69 m/sec, and the rms miss at Venus is about 140 km and at Mercury about 5000 km. It is concluded that the results of the analysis indicate the engineering feasibility of the Earth-Venus-Mercury mission.

S41 TRAJECTORY ANALYSIS OF AN EARTH-VENUS-MERCURY MISSION IN 1973

Sturms, F. M., Jr.

Technical Report 32-1062, January 1, 1967

(Unclassified)

Results are given of a preliminary study of trajectory and guidance considerations for an Earth-Venus-Mercury mission in 1973. The mission utilizes a trajectory having a close encounter with Venus enroute to Mercury to reduce launch-energy requirements. Conic trajectory data are presented for the region of possible trajectories having launch energies less than $21 \text{ km}^2/\text{sec}^2$. Integrated trajectory data and near-planet geometry are presented for selected mission designs. Based on a maximum launch energy of $19.5 \text{ km}^2/\text{sec}^2$ and a constant Venus arrival date of February 5, 1974, the resulting launch period is 23 days, extending from October 20 to November 11, 1973. The total flight times range from 131 to 165 days, with Mercury encounter near the end of March 1974. The mission can be accomplished with Earth-based radio tracking and three midcourse corrections at times about 6 days after injection,

6 days before Venus encounter, and 8 days after Venus encounter. Statistics are presented for the three midcourse corrections and associated target errors. A total midcourse velocity capability of about 120 m/sec is required. The final rms miss at Mercury ranges from 1400 to 2900 km.

Summers, R. H.

S42 RANGER BLOCK III ATTITUDE CONTROL SYSTEM: MANUFACTURING, TESTING AND PERFORMANCE

Almaguer, T. A., Jr., Baxter, T. G., Hand, P. J.,

Perkins, G. S., Summers, R. H.

Technical Report 32-915, September 15, 1966

(Unclassified)

For abstract, see Almaguer, T. A., Jr.

Thompson, R. P.

T01 THE PRACTICAL PROBLEM OF LANDING ON MARS

Thompson, R. P.

Technical Report 32-1009 (Unclassified)

(Reprinted from *Astronautics and Aeronautics*, Vol. 4, No. 7, July 1966, pp. 66-73)

This is a discussion of problems connected with landing a spacecraft on Mars. The design of the first lander should be as simple and conservative as possible. It should be able to withstand thorough testing and designed with the goal that no single failure mode will cause catastrophic failure of the mission. Independent backup, accordingly, should be provided for every critical event in the sequence, and the selective use of redundancy must be used to achieve high reliability. The capsule should be instrumented to allow diagnosis of failures, whether caused by a system malfunction or by the encountering of an unexpected environment.

Trask, D. W.

T02 PHYSICAL CONSTANTS AS DETERMINED FROM RADIO TRACKING OF THE RANGER LUNAR PROBES

Sjogren, W. L., Trask, D. W., Vegos, C. J.,

Wollenhaupt, W. R.

Technical Report 32-1057, December 30, 1966

(Unclassified)

For abstract, see Sjogren, W. L.

Turkevich, A.

T03 INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS

Turkevich, A., Knolle, K., Emmert, R. A., Anderson, W. A.,

Patterson, J. H., Franzgrote, E.

Technical Report 32-1065 (Unclassified)

(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 12, December 1966, pp. 1681-1686)

An instrument has been designed and constructed which utilizes the interactions of monoenergetic alpha particles with

matter for surface chemical analysis. The source of alpha particles is a radioactive nuclide, such as ^{242}Cm . The energy spectra of backscattered alpha particles are measured with semiconductor detectors. Other detectors (with gold foils over them to eliminate alpha particles) register protons from α, p reactions. Transistorized electronics provide 128-channel pulse height analyzers for both alpha and proton spectra. The first prototype instrument designed for the *Surveyor* lunar missions weighs less than 4 kg and uses less than 1.3 w.

T04 CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION

Turkevich, A., Knolle, K., Franzgrote, E., Patterson, J. H.
Technical Report 32-1090 (Unclassified)
(Reprinted from *Journal of Geophysical Research*,
Vol. 72, No. 2, January 15, 1967, pp. 831-839)

An experiment has been designed to determine the chemical composition of the lunar surface during the *Surveyor* soft-landing science missions to the Moon. The instrument utilizes the characteristic spectrums of backward-scattered α particles and protons from (α, p) reactions to establish the elements present in a sample. The instrument can determine the amounts of most elements present in rocks with a sensitivity and accuracy of about 1 at.%. Satisfactory analyses of a variety of terrestrial samples have been obtained.

Tyler, W. H.

T05 AN EXPERIMENTAL EVALUATION OF 100-lb-THRUST ABLATIVELY COOLED ROCKET ENGINES

Tyler, W. H., Porter, R. N.
Technical Report 32-978, October 1, 1966
(Unclassified)

Five 100-lb-thrust ablatively cooled chambers, designed and fabricated by industrial companies, were subjected to test firings in a partial assessment of the state of the art of this type of chamber design. The severity of the test conditions (nitrogen tetroxide and hydrazine burned at a nominal pressure of 150 psia) caused all but two of the chambers to fail or erode excessively before 500 sec of firing time had elapsed. Both of the more resistant chambers had hard throat inserts of silicon carbide or molybdenum.

Utku, S.

U01 ON THE IMPACT INDUCED STRESS WAVES IN LONG BARS

Utku, S.
Technical Report 32-932, July 15, 1966
(Unclassified)

The work discussed in this Report is confined to the initial impactive behavior of uniform prismatic bars of constant pre-impactive velocity. Various nonlinear stress-strain relationships with no strain-rate effect are considered. The fact that the bar is laterally unconfined is taken into account in the equation of

conservation of mass. The lateral motion is ignored; however, its effect is discussed during the derivation of Rankine-Hugoniot equations for the impacting bar of strain-hardening material. For the case of no strain hardening, the analysis in an Eulerian reference system is carried out with the method of characteristics until the occurrence of first unloading. Various formulas are derived for the possible iterative computation of stresses, strains, and velocities. The general behavior of energy dissipators is studied by means of a bar of elastoplastic material with infinite strain hardening. It is shown that the bar will be crushed from both ends and, provided that lateral motion is prevented, it is also shown that the shock temperatures are helpful in energy dissipation. This paper indicates the number of measurements required for obtaining the first estimate of mechanical properties of the unknown impacted surface when the properties of the impacting bar are unknown.

U02 COMPUTATION OF STRESSES IN TRIANGULAR FINITE ELEMENTS

Utku, S.
Technical Report 32-948, June 15, 1966
(Unclassified)

The work described in this Report is concerned with the calculation of stresses in linear thin shells of aeolotropic material using the deflections obtained by the finite-element method. When displacements and rotations of a thin shell or plate middle surface are known at sufficiently many nodal points, approximations for the stress resultants and couples may be computed by (1) distributing the nodal forces and moments of a triangular element along nodal lines, (2) obtaining a best-fit deflection field in the triangle from the available nodal deflections and using this field in the computation of strains and curvature changes, (3) obtaining best-fit displacement distributions along nodal lines from available nodal deflections and computing the components of best-fit strain and curvature-change tensors at nodes by least-squares from these distributions, and, finally, (4) combining the methods described in (2) and (3). Methods (1) and (2) enable one to keep the modular character of the finite element scheme. Methods (3) and (4) are semimodular, since they require information at all the neighboring nodes in order to compute the stresses at a node. These methods are formulated and discussed, and it is shown that the curvatures of the middle surface may be taken into account in all four instances.

Vegos, C. J.

V01 PHYSICAL CONSTANTS AS DETERMINED FROM RADIO TRACKING OF THE RANGER LUNAR PROBES

Sjogren, W. L., Trask, D. W., Vegos, C. J.,
Wollenhaupt, W. R.
Technical Report 32-1057, December 30, 1966
(Unclassified)

For abstract, see Sjogren, W. L.

Volkoff, J. J.

**V02 PRELIMINARY INVESTIGATIONS TO DETERMINE
NUCLEAR-ELECTRIC SPACECRAFT
CONFIGURATIONS FOR HIGH-ENERGY MISSIONS**

Volkoff, J. J., Womack, J. R.

Technical Report 32-1085, March 15, 1967

(Unclassified)

This Report determines how the mass of spacecraft systems is affected by changes in spacecraft configuration for a conceptual 500-kwe nuclear-electric spacecraft designed for a Jupiter orbital mission. The power plant employs a reactor-turbo-generator system. The nuclear-radiation shield, heat-rejection radiators, spacecraft structure, booster-spacecraft adapter, and aerodynamic shroud are considered as subsystems most likely to vary appreciably in mass with changes of spacecraft configuration. The two selected spacecraft configuration concepts feature the heat-rejection radiator systems assembled in the flat-plane configuration and the cylindrical configuration. The flat-plane radiator configuration was found to be the more favorable concept.

Vrebalovich, T.

**V03 GRID TURBULENCE AT LARGE
REYNOLDS NUMBERS**

Kistler, A. L., Vrebalovich, T.

Technical Report 32-985 (Unclassified)

(Reprinted from *Journal of Fluid Mechanics*, Vol. 26,
Part 1, 1966, pp. 37-47)

For abstract, see Kistler, A. L.

V04 PROCEEDINGS OF THE LUNA 9 SYMPOSIUM

Vrebalovich, T.

Technical Memorandum 33-294, November 1, 1966

(Unclassified)

The *Luna 9* Symposium was held at JPL on February 19, 1966, to discuss the photographs obtained by the Soviet Union's *Luna 9* spacecraft, which had landed on the Moon on February 3, 1966. The discussion was not directed toward the flight profile or the spacecraft itself; instead, the papers presented were primarily concerned with the interpretation of the surface of the Moon, as revealed in the photographs. These *Proceedings* include those papers formally submitted after the meeting. Only an abstract of a paper by E. M. Shoemaker is included: the paper itself has been published in *Astronautics and Aeronautics*. Included in the Appendix is the best set of photographs available that comprise a complete panorama taken by the facsimile camera on *Luna 9*. A photograph of the *Luna 9* spacecraft appears in the frontispiece.

Wada, B. K.

**W01 DESIGN, FABRICATION, AND TESTING OF THE
APPLICATIONS TECHNOLOGY SATELLITE
APOGEE MOTOR CHAMBER**

Lardenoit, V. F., Wada, B. K., Kohorst, D. P.

Technical Memorandum 33-309, November 1, 1966

(Unclassified)

For abstract, see Lardenoit, V. F.

Wagner, R. I.

**W02 NUCLEAR MAGNETIC RESONANCE OF
PHOSPHORUS COMPOUNDS.
II. THE RELATIVE SIGNS OF THE SPIN-SPIN
COUPLINGS IN DIMETHYLPHOSPHINE
AND METHYLPHOSPHINE**

Manatt, S. L., Juvinall, G. L., Wagner, R. I., Elleman, D. D.

Technical Report 32-974 (Unclassified)

(Reprinted from *Journal of the American Chemical
Society*, Vol. 88, No. 12, June 20, 1966, pp. 2689-2697)

For abstract, see Manatt, S. L.

Weinberg, E.

**W03 COMPARISON OF LIQUID-METAL
MAGNETOHYDRODYNAMIC POWER
CONVERSION CYCLES**

Weinberg, E., Hays, L. G.

Technical Report 32-946, July 1, 1966

(Unclassified)

Various two-phase liquid-metal magnetohydrodynamic (MHD) power conversion cycles employing either a separator or jet condenser are compared on the basis of cycle efficiency, prime radiator area, and specific weight. The cycles are investigated first from the standpoint of coalescence on a wall (of the separator or jet condenser) with attendant friction and deflection energy losses and, second, from the standpoint of liquid coalescence with no friction or deflection energy losses. The results of this study for the first condition show that (1) the two-component cycles, both separator and condenser (employing lithium and cesium), have efficiencies of 6 to 7%, while the single-component cycles (one chemical species—cesium or potassium) have maximum efficiencies of only 3 to 4%, and (2) the two-component separator cycle (cesium-lithium) has a slightly higher efficiency and smaller radiator area than the two-component condenser cycles (cesium-lithium), if 100% liquid impingement is assumed on the condenser and separator walls. For the second condition—operation without separator and condenser friction or deflection—it was shown that (1) the two-component cycles require about half as much radiator area as the single-component cycles, for a given efficiency, and (2) the efficiency of the two-component condenser cycles (cesium-lithium) increases indefinitely with

decreasing rejection temperature, while the efficiency of the two-component separator cycle (cesium-lithium) is limited to 13%. It thus appears that the most promising cycle for space applications is the two component (cesium-lithium) separator cycle, if 100% liquid impingement occurs on the walls of the jet condenser and on the separator. The two-component (cesium-lithium) condenser cycles appear promising for ultimate high efficiency, should it be possible to eliminate condenser friction.

Weinberg, I.

W04 THERMOELECTRIC POWER IN SILVER-GOLD AND SILVER-GERMANIUM ALLOYS

Weinberg, I.

Technical Report 32-1060, January 1, 1967

(Unclassified)

The thermoelectric powers of dilute silver-gold (Ag-Au) and silver-germanium (Ag-Ge) alloys from 78 to 300°K are described, Nordheim-Gorter plots are given for these alloy systems at 273 and 295°K, and the characteristic thermopowers S_s^1 and S_s^0 , attributed to solute and solvent, respectively, are determined at these temperatures. Calculated values of S_s^1 for both alloy systems agree in sign and approximate magnitude with the experimental values. For Ag-Au, small or negligible Fermi surface changes are indicated up to the maximum Au concentration of 1.5 at.%. This is in agreement with recent conclusions based on polar-reflection Faraday experiments with Ag-Au. The Ag-Ge data, however, deviate from the expected linearity predicted by the Nordheim-Gorter relationship at approximately 0.5 at.%. The deviation in the Ag-Ge case is attributed to Fermi surface changes as a result of alloying. A detailed comparison of the current Ag-Au data with previous results for Cu-Ag and Cu-Au is carried out, using a Nordheim-Gorter-type relationship for the difference in thermopower ΔS between the pure metal and alloy. It is found that, for a given solute concentration, ΔS is greatest in Ag-Au, decreases in Cu-Au, and is still less in Cu-Ag. It is concluded that the observed ΔS differences are attributable to a possible combination of small Fermi surface changes and slight differences in electronic charge associated with the solute atoms when compared to the host atom in these alloys.

W05 DIFFUSION THERMOPOWER AND THE FERMI SURFACE IN DILUTE SILVER-GOLD ALLOYS

Weinberg, I.

Technical Report 32-1095 (Unclassified)

(Reprinted from *Journal of Physics and Chemistry of Solids*, Vol. 28, Pergamon Press, 1967, pp. 702-704)

The thermoelectric power of several high-purity silver-gold alloys is determined from 77 to 300°K. Resistivities at 4.2 and 273°K, together with solute concentrations, are determined by chemical analysis. Concentrating on S_s , the diffusion component of the thermopower, the data are compared with expect-

tations based on current theory and experiment. Results are interpreted to determine if the variations in thermoelectric power are attributable to significant Fermi surface changes.

Weiner, R. S.

W06 BASIC CRITERIA AND DEFINITIONS FOR ZERO FLUID LEAKAGE

Weiner, R. S.

Technical Report 32-926, December 15, 1966

(Unclassified)

This Report defines both liquid and gaseous zero leakage over a pressure range from 1.0 and 0.1 psi, respectively, to 10,000 psi. Graphs are included for clarity. The zero-liquid-leakage graph contains an equivalent gaseous-helium test leakage curve. A fluid-flow conversion nomograph, constructed from certain applications of the Poiseuille equation, is included to help simplify efforts of specification writers and test personnel in obtaining equivalent flow rates between fluids over a wide range of pressures and temperatures. Leak test methods and test techniques are also discussed. The information presented has important applications to such current projects as *Mariner* and *Surveyor*.

Wells, W. H.

W07 MODES OF A TILTED-MIRROR OPTICAL RESONATOR FOR THE FAR INFRARED

Wells, W. H.

Technical Report 32-959 (Unclassified)

(Reprinted from *IEEE Journal of Quantum Electronics*, Vol. QE-2, No. 5, May 5, 1966, pp. 94-102)

In an extension of the work of A. G. Fox and T. Li of Bell Telephone Laboratories, a study was made of the modes of tilted-plane mirrors having enough tilt to use the spillover radiation (at a straight edge) as output coupling. This geometry seems desirable as an oscillator to intercept a molecular beam and extract coherent power in the far infrared. Control of the tilt angle provides variable Q. Amplitude and phase of the output are smooth enough to use cylindrical optics for focusing or collimating the output.

The three lowest-order two-dimensional modes were studied which, under reasonable conditions, are determined by a single parameter. It is $\beta = \alpha(b/\lambda)^{1/2}$, where α = mirror tilt, b = mirror separation, and λ = wavelength. The lowest mode (TEM_0) has loss per pass that increases almost linearly from 3 percent at $\beta = 10^{-2}$ to 37 percent at $\beta = 10^{-1}$. The output appears to diverge from a vertical source about $3b$ behind the spillover edge of the shorter mirror. The virtual source of the lowest mode is displaced $(0.7 \text{ to } 1.1)(\lambda b)^{1/2}$ inward from the spillover edge.

The mathematical problem proved to be an interesting exercise in devising ways to isolate an eigenfunction of an integral operator when the eigenvalues are nearly equal.

Wesseling, P.

W08 A TWO-VARIABLE ASYMPTOTIC SOLUTION FOR THREE-DIMENSIONAL, SOLAR-POWERED, LOW-THRUST TRAJECTORIES IN THE VICINITY OF THE ECLIPTIC PLANE

Wesseling, P.

Technical Report 32-1053, March 15, 1967

(Unclassified)

An approximate analytic solution is derived for the variables which describe a three-dimensional, solar-powered, heliocentric, low-thrust trajectory in the vicinity of the ecliptic plane. This approximate solution consists of the first three terms of an asymptotic series, valid in the limit of vanishing thrust. To obtain an extended domain of validity, the two-variable method is used.

The results are compared with numerical integrations of the equations of motion, and the difference between the results of the two methods is found to be minimal. No signs of growing errors are discovered, and the computing time is appreciably less than the time needed to perform numerical integrations of the equations of motion. It is concluded that the asymptotic series derived in this Report is a useful tool for the design of solar-powered, interplanetary, low-thrust trajectories.

Whitehead, A. B.

W09 PULSE HEIGHT DEFECT AND ENERGY DISPERSION IN SEMICONDUCTOR DETECTORS

Haines, E. L., Whitehead, A. B.

Technical Report 32-891 (Unclassified)

(Reprinted from *The Review of Scientific Instruments*, Vol. 37, No. 2, February 1966, pp. 190-194)

For abstract, see Haines, E. L.

Wiksten, D. B.

W10 SHOCK-SPECTRUM ANALYSIS PROGRAM

Snyder, D. C., Wiksten, D. B.

Technical Memorandum 33-326, March 1, 1967

(Unclassified)

For abstract, see Snyder, D. C.

Williams, H. E.

W11 AXISYMMETRIC THERMAL STRESSES IN SANDWICH SHELLS OF REVOLUTION WITH APPLICATION TO SHALLOW, SPHERICAL SHELLS

Williams, H. E.

Technical Report 32-920, May 1, 1966

(Unclassified)

The problem of computing the thermal stresses in a sandwich shell of revolution with a weak core is approached by computing separately a particular solution of the equations that involve the temperature distribution, and then superposing a solution for an edge-loaded shell to satisfy the boundary con-

ditions. The component solutions for a shallow spherical shell are included in the Report. In order to retain the effects of transverse normal and shear strain, the governing equations of equilibrium and the stress-strain relations are obtained by applying Reissner's variational principle. The particular solution for the heated shell is obtained by an order of magnitude argument and is applicable for slowly varying temperature distributions only. The solutions for the edge-loaded shell indicate that the cross influence coefficients (rotation due to a force, etc.) can be obtained from those of an equivalent isotropic shell, but that the direct influence coefficients (displacement due to a force, etc.) are substantially affected by the effect of transverse shear strain. The effect of transverse normal strain is appreciable only in the particular solution.

Willingham, D. E.

W12 RANGER VII PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.

Technical Report 32-964, November 1, 1966

(Unclassified)

For abstract, see Kirhofer, W. E.

W13 RANGER VIII PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.

Technical Report 32-965, November 1, 1966

(Unclassified)

For abstract, see Kirhofer, W. E.

W14 RANGER IX PHOTOGRAPHIC PARAMETERS

Kirhofer, W. E., Willingham, D. E.

Technical Report 32-966, September 15, 1966

(Unclassified)

For abstract, see Kirhofer, W. E.

W15 MISSION TO A COMET: PRELIMINARY SCIENTIFIC OBJECTIVES AND EXPERIMENTS FOR USE IN ADVANCED MISSION STUDIES

Brereton, R. G., Newburn, R. L., Giffin, C. E.,

Neugebauer, M. M., Smith, E. J., Willingham, D. E.

Technical Memorandum 33-297, February 15, 1967

(Unclassified)

For abstract, see Brereton, R. G.

Wolf, F. J.

W16 THE SURVEYOR LUNAR LANDING TELEVISION SYSTEM

Montgomery, D. R., Wolf, F. J.

Technical Report 32-1008 (Unclassified)

(Reprinted from *IEEE Spectrum*, August 1966, pp. 54-61)

For abstract, see Montgomery, D. R.

Wollenhaupt, W. R.

**W17 PHYSICAL CONSTANTS AS DETERMINED FROM
RADIO TRACKING OF THE RANGER
LUNAR PROBES**

Sjogren, W. L., Trask, D. W., Vegos, C. J.,
Wollenhaupt, W. R.

Technical Report 32-1057, December 30, 1966
(Unclassified)

For abstract, see Sjogren, W. L.

Womack, J. R.

**W18 PRELIMINARY INVESTIGATIONS TO DETERMINE
NUCLEAR-ELECTRIC SPACECRAFT
CONFIGURATIONS FOR HIGH-ENERGY MISSIONS**

Volkoff, J. J., Womack, J. R.

Technical Report 32-1085, March 15, 1967
(Unclassified)

For abstract, see Volkoff, J. J.

Wong, R. Y.

**W19 DESIGN, DEVELOPMENT, TESTING AND FLIGHT
PERFORMANCE OF MARINER MARS PLANETARY
SCAN SYSTEM**

Wong, R. Y.

Technical Report 32-919, July 1, 1966
(Unclassified)

The planetary scan system was designed and developed to support the planetary encounter activities of the *Mariner* Mars 1964 mission. Its primary functions are to search for, acquire and track the planet Mars in order to orient the television camera properly during the period immediately preceding the TV picture-recording sequence. This Report describes the design, development, fabrication, testing, and performance of the system.

Woodbury, R. C.

**W20 SPECTRAL ANALYSIS APPLIED TO A DIGITALLY
CODED PM RF CARRIER**

Woodbury, R. C.

Technical Report 32-893, August 15, 1966
(Unclassified)

To ensure a high degree of confidence in calibrating a digitally coded phase-modulated (PM) system, it is desirable to calibrate directly in terms of the digital modulation. The complexity of the spectra resulting from the single-tone case suggests that the spectra from a digitally modulated PM system must be extremely complex and are, therefore, not usable for direct calibrations.

This Report demonstrates that the contrary is true, by investigating the spectrum of a square-wave PM carrier. It is shown that the spectra obey simple relationships which permit accurate calibration of a PM system.

The geometric tolerances of the square- and trapezoidal-wave modulation functions are investigated in terms of har-

monic content. It is shown that the symmetry and the rise-time of these functions provide a sensitive indication of the performance of a PM system.

Wright, F. H.

**W21 FAILURE RATE COMPUTATIONS BASED ON
MARINER MARS 1964 SPACECRAFT DATA**

Wright, F. H.

Technical Report 32-1036, November 15, 1966
(Unclassified)

This Report describes the analysis of spacecraft parts-hours and presents failure rates obtained during the *Mariner* Mars 1964 project for transistors, resistors, capacitors, diodes, transformers, relays, and coils, using the JPL problem/failure reporting system. Failure data origins, ground rules and definitions are also given.

Wrobel, J. R.

**W22 SURVEYOR VERNIER ENGINE FUEL BLEND—
A CONSTRAINED OPTIMIZATION**

Wrobel, J. R., Grelecki, C.

Technical Report 32-1102 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 4,
No. 3, March 1967, pp. 347-353)

Development testing with monomethyl-hydrazine (MMH) in the regeneratively fuel-cooled RMD-TD 280 *Surveyor* thrust chamber revealed that decomposition of the coolant under transient thrust extremes deteriorated the cooling characteristics of the engine. Water addition and mixture ratio changes were studied as perturbations to the neat fuel conditions for cooling-jacket temperature rise, total impulse, and heat capacity. The selected operating point was at mixture ratio 1.5, and a fuel blend of 72% MMH/28% water, which is the composition for monomethyl-hydrazine monohydrate. The physical properties of the blends confirmed that a compound having this composition formed in solution. Upon heating, the hydrate endothermically dissociated to enhance the fuel heat capacity. Experiments demonstrated that the neat MMH decomposition rate is about five times greater than that of the 72/28% mixture. Selected correlations with data from the subsequent engine testing are presented to demonstrate the validity of the parametric study and to illustrate the trends in heat transfer, specific impulse, and throat erosion.

Wu, C.-S.

**W23 HIGH-FREQUENCY CONDUCTIVITY OF A PLASMA
IN QUASI-EQUILIBRIUM.**

III. STUDY OF A TWO-TEMPERATURE PLASMA

Klevans, E. H., Wu, C.-S.

Technical Report 32-1013 (Unclassified)
(Reprinted from *The Physical Review*, Vol. 149, No. 1,
September 9, 1966, pp. 141-154)

For abstract, see Klevans, E. H.

Zmuidzinas, J. S.

Z01 UNITARY REPRESENTATIONS OF THE LORENTZ GROUP ON 4-VECTOR MANIFOLDS

Zmuidzinas, J. S.

Technical Report 32-935 (Unclassified)

(Reprinted from *Journal of Mathematical Physics*, Vol. 7, No. 4, April 1966, pp. 764-780)

A review is presented of irreducible unitary representations of the $(3 + 1)$ -dimensional restricted Lorentz group on manifolds of time-, light-, and spacelike 4-vectors. In each case a complete set of orthonormal (in the sense of the distribution theory) basis functions is available. The completeness relation for the nontrivial spacelike case is proved in detail. Expansion formulas, Lorentz-group analogs of the Fourier integral theorem, are given. In particular, expansions of plane-wave-solutions of the Klein-Gordon equation for $-\infty < m^2 < \infty$ are worked out as an illustrative example. Possible physical applications are briefly discussed.

Z02 QUARK MODEL OF LEPTONS

Zmuidzinas, J. S.

Technical Report 32-1082, May 1, 1967 (Unclassified)

A model is proposed in which leptons are deeply bound states of certain combinations of quarks and quirks (R -conjugates of quarks), as well as of their antiparticles. The mass splittings of the leptons are estimated using the static model with unitary-symmetric meson exchange forces and are found in rough agreement with experiment, provided one uses the quark mass differences implied by the quark model of hadrons. A new charged spin- $1/2$ lepton, λ^\pm , is predicted with mass $\gtrsim M_{\text{pion}}$. Weak interactions of known leptons and λ^\pm are examined from the viewpoint of the model. The electromagnetic decay $\mu \rightarrow e + \gamma$ is strictly forbidden. Rough dynamical arguments are presented to explain why leptons should be devoid of strong interactions.

Zukoski, E. E.

Z03 A STUDY OF SECONDARY INJECTION OF GASES INTO A SUPERSONIC FLOW

Spaid, F. W., Zukoski, E. E., Rosen, R.

Technical Report 32-834, August 1, 1966
(Unclassified)

For abstract, see Spaid, F. W.

Space Programs Summary

The *Space Programs Summary* is a six-volume, bimonthly summary report that documents the current project activities and supporting research and advanced development efforts conducted, or managed, by the Jet Propulsion Laboratory for the National Aeronautics and Space Administration space exploration programs. This publication provides the National Aeronautics and Space Administration, other elements of the government, major aerospace contractors, and colleges and universities with technical information concerning the various Jet Propulsion Laboratory programs and projects. An equally important purpose of the *Space Programs Summary* is to provide technical information to Jet Propulsion Laboratory employees and to act as a storage source of information for later use in Laboratory *Technical Reports*.

AB01 THE LUNAR PROGRAM

Space Programs Summary, Vol. I (Confidential)
37-40, (May 1 to June 30, 1966), July 31, 1966
37-41, (July 1 to August 31, 1966), September 30, 1966
37-42, (September 1 to October 31, 1966), November 30, 1966
37-43, (November 1 to December 31, 1966), January 31, 1967
37-44, (January 1 to February 28, 1967), March 31, 1967
37-45, (March 1 to April 30, 1967), May 31, 1967

Volume I is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Lunar Program; the project presently covered is *Surveyor*. The general areas included are conception, design, research, development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses.

AB02 THE PLANETARY-INTERPLANETARY PROGRAM

Space Programs Summary, Vol. II (Confidential)
37-40, (May 1 to June 30, 1966), July 31, 1966
37-41, (July 1 to August 31, 1966), September 30, 1966
37-42, (September 1 to October 31, 1966), November 30, 1966
37-43, (November 1 to December 31, 1966), January 31, 1967
37-44, (February 1 to March 31, 1967), April 30, 1967

Volume II is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Planetary-Interplanetary Program; presently covered are the *Mariner Venus 67*, *Mariner Mars 1969*, and *Voyager* Projects. The general areas included are conception, design, research,

development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses. Study efforts related to future projects are also reported.

AB03 THE DEEP SPACE NETWORK

Space Programs Summary, Vol. III (Unclassified)
37-39, (March 1 to April 30, 1966), May 31, 1966
37-40, (May 1 to June 30, 1966), July 31, 1966
37-41, (July 1 to August 31, 1966), September 30, 1966
37-42, (September 1 to October 31, 1966), November 30, 1966
37-43, (November 1 to December 31, 1966), January 31, 1967
37-44, (January 1 to February 28, 1967), March 31, 1967

Volume III is a bimonthly summary report of the current facility-project activities that have application to the JPL/NASA Deep Space Network (DSN); the facilities covered are the Deep Space Instrumentation Facility, Space Flight Operations Facility, and the DSN Ground Communication System. The general subjects and areas included are (1) *facility* design, fabrication and assembly, and system testing, (2) *communication components and systems* conception, design, research, development, developmental testing, and engineering analysis, and (3) *tracking* conception, design, system testing, preflight and flight operations, and engineering analysis.

AB04 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT

Space Programs Summary, Vol. IV (Unclassified)
37-39, (April 1 to May 31, 1966), June 30, 1966
37-40, (June 1 to July 31, 1966), August 31, 1966

- 37-41, (August 1 to September 30, 1966), October 31, 1966
 37-42, (October 1 to November 30, 1966), December 31, 1966
 37-43, (December 1, 1966 to January 31, 1967), February 28, 1967
 37-44, (February 1 to March 31, 1967), April 30, 1967
 37-45, (April 1 to May 31, 1967), June 30, 1967

Volume IV is a bimonthly summary report of the current *unclassified* supporting research and advanced development activities that have application to the JPL/NASA space exploration programs. The general subject areas include aerodynamics, celestial mechanics, chemistry, computers, electrical power supply, electronics, environmental simulators, exobiology, fluid flow, guidance and control, instrumentation, space sciences, materials, mathematics, microbiology, physics, polymers, propellants, propulsion systems, quality assurance and reliability, structural mechanics, telecommunications, test facilities, and thermodynamics and combustion.

AB05 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT

- Space Programs Summary, Vol. V (Confidential)
 37-40, (April 1 to July 31, 1966), August 31, 1966
 37-41, (June 1 to September 30, 1966), October 31, 1966
 37-44, (February 1 to March 31, 1967), April 30, 1967

Volume V is a bimonthly summary report of the current *classified* supporting research and advanced development activities that have application to the JPL/NASA space exploration programs.

AB06 SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES

- Space Programs Summary, Vol. VI (Unclassified)
 37-40, (May 1 to June 30, 1966), July 31, 1966
 37-41, (July 1 to August 31, 1966), September 30, 1966
 37-42, (September 1 to October 31, 1966), November 30, 1966
 37-43, (November 1 to December 31, 1966), January 31, 1967
 37-44, (January 1 to February 28, 1967), March 31, 1967

Volume VI is a bimonthly publication consisting of: (1) an unclassified digest of appropriate material from Volumes I, II, and III; (2) a reprint of the space science instrumentation studies of Volumes I and II; and (3) beginning with *Space Programs Summary* 37-31, an original presentation of technical supporting activities, including engineering development of environmental-test facilities, and quality assurance and reliability. The purpose of this Volume is to present a brief, generalized report of activities especially suitable for distribution to the scientific community. Additional space science studies are reported in Volume IV.

JPL Reporting in the Open Literature

This section lists engineering and scientific articles by JPL technical personnel which have been published in the open literature — either domestic or foreign. Articles from the open literature which have been reprinted and published as JPL Technical Reports are included in the preceding section, "Technical Reports and Memorandums."

Chahine, M.

- AD01 ON THE SOLUTION OF THE BOLTZMANN EQUATION FOR A TWO-DIMENSIONAL GAS
Chahine, M.
Rarefied Gas Dynamics, 5th Symposium, Vol. I, 1967,
pp. 711-729

The Boltzmann equation and the statistical properties for a two-dimensional gas are developed, an integral iteration scheme for the shock wave flow problem is analyzed, and an analytical approach based on a Mott-Smith distribution function is presented.

- AD02 THEORETICAL AND EXPERIMENTAL ASPECTS OF THE SHOCK STRUCTURE PROBLEM
Liepmann, H. W., Narasimha, R., Chahine, M.
(Reprinted from *Applied Mechanics*, "Proceedings of the Eleventh International Congress of Applied Mechanics," Munich (Germany) 1966, pp. 973-979)
(Springer-Verlag, Berlin-Heidelberg-New York)

For abstract, see Liepmann, H. W.

Chen, C. J.

- AD03 EXPERIMENTAL EVIDENCE OF INVERSE BREMSSTRAHLUNG AND ELECTRON-IMPACT IONIZATION IN LOW-PRESSURE ARGON IONIZED BY A GIANT-PULSE LASER
Chen, C. J.
Physical Review Letters, Vol. 16, No. 19,
May 9, 1966, pp. 833-835

In this Letter experimental evidence is presented which shows that at low pressures (less than one atmosphere) most of the electrons are produced after the cessation of the laser pulse, and the ionization rise time is increased as the pressure of the gas is decreased. It is also shown that the most probable mechanism for electron production is due to inverse bremsstrahlung and subsequent electron-impact ionization.

It is therefore concluded that the ionization process in the argon gas irradiated by a laser beam is inverse bremsstrahlung and electron inelastic collisions. The evidence supporting the electron impact process in high-pressure gases has recently been published.

Davies, R. W.

- AD04 PLANETARY CONTAMINATION I: THE PROBLEM AND THE AGREEMENTS
Horowitz, N. H., Sharp, R. P., Davies, R. W.
Science, Vol. 155, No. 3769, March 24, 1967,
pp. 1501-1505

For abstract, see Horowitz, N. H.

Drummond, A. J.

- AD05 MULTICHANNEL RADIOMETER MEASUREMENT OF SOLAR IRRADIANCE
Drummond, A. J., Hickey, J. R., Scholes, W. J., Laue, E. G.
AIAA 5th Aerospace Sciences Meeting, New York,
January 23-26, 1967
AIAA Paper No. 67-147, pp. 1-11

A unique experiment has been proposed as an essential requirement for solving problems involved in attaining the necessary radiative equilibrium of spacecraft, particularly in deep space voyages. A 12-channel radiometer incorporating fast-response, high-sensitivity, wirewound-plated thermopiles, lenses, and optical bandpass filters was developed for measuring extra-terrestrial solar irradiance and selected spectral components. The filters were constructed to explore the wavelength regions wherein the distributions of Johnson and Nicolet show the greatest divergence. The signal conditioner includes a 24-channel commutator with a switching rate of up to 16 channels/sec, a dc differential amplifier with a gain of approximately $\times 1000$, and a 28-v dc-dc power converter. The signals (voltages) are fed to a galvanometer oscillograph in the case of the U.S. Air Force/NASA X-15 rocket research aircraft, and to a digital voltmeter printer for the NASA B-57 jet aircraft. Similar instrumentation is employed on the ground. The first results (B-57 flights) suggest a value for the integral wavelength solar constant that is 2.5% lower than the value proposed by Johnson. For wavelengths less than 600 nanometers, the suggested value is about 6% lower than the Johnson value. There is good agreement in the infrared region. The X-15 results will be reported when they become available.

Gray, L. D.

AD06 CALCULATIONS OF CARBON DIOXIDE TRANSMISSION.

PART I. THE 9.4 μ AND 10.4 μ BANDS

Gray, L. D.

Journal of Quantitative Spectroscopy and Radiative Transfer, Vol. 7, Pergamon, Ltd., pp. 143-150

The random-Elsasser band model is used to compute the spectral transmission of CO₂, and comparisons are made with published experimental measurements. The best agreement between calculated and observed values of transmission is obtained when the following values of integrated intensity are used: $S(02^{\circ}0-00^{\circ}1) = 0.030 \text{ cm}^{-1}/\text{cm atm}_{\text{s.t.p.}}$ and $S(10^{\circ}0-00^{\circ}1) = 0.019 \text{ cm}^{-1}/\text{cm atm}_{\text{s.t.p.}}$ at 300°K.

Hickey, J. R.

AD07 MULTICHANNEL RADIOMETER MEASUREMENT OF SOLAR IRRADIANCE

Drummond, A. J., Hickey, J. R., Scholes, W. J.,

Laue, E. G.

AIAA 5th Aerospace Sciences Meeting, New York, January 23-26, 1967

AIAA Paper No. 67-147, pp. 1-11

For abstract, see Drummond, A. J.

Horowitz, N. H.

AD08 PLANETARY CONTAMINATION I: THE PROBLEM AND THE AGREEMENTS

Horowitz, N. H., Sharp, R. P., Davies, R. W.

Science, Vol. 155, No. 3769, March 24, 1967, pp. 1501-1505

When the physical and biological assumptions underlying the sterility requirements for landed spacecraft (tentatively adopted by the Committee on Space Research [COSPAR] of the International Council of Scientific Unions) are compared with actual conditions on Mars, as established by recent observations, it becomes apparent that the COSPAR assumptions are unrealistic in important respects. Findings suggest that the COSPAR-recommended constraints could be substantially relaxed without compromising to any significant degree the biological condition of Mars. Current spacecraft-sterilization policies should be revised accordingly.

Jaffe, L. D.

AD09 SURFACE STRUCTURE AND MECHANICAL PROPERTIES OF THE LUNAR MARIA

Jaffe, L. D.

Journal of Geophysical Research, Vol. 72, No. 6, March 15, 1967, pp. 1727-1731

Strain gage and television data from *Surveyor I*, as well as earlier measurements from the Earth and the spacecraft, are consistent with the following characteristics for undisturbed

mare surface: a structure composed of individual particles, for the most part 100 μ or less in diameter, and with a small percentage at millimeter-to-meter sizes. The density of the top few centimeters is about 0.7 g/cm³, corresponding to about 25% solid. The static bearing capacity is about 4×10^5 dynes/cm² on a 25-cm bearing diameter with no sinkage, increasing at the rate of about 2×10^4 dynes/cm³ with sinkage. Cohesion is between 10² and 10⁵ dynes/cm², most probably about 10³ dynes/cm². The coefficient of internal friction is most probably about 1.5 but may be somewhat lower. The failure mode under bearing load is primarily local shear.

Laue, E. G.

AD10 MULTICHANNEL RADIOMETER MEASUREMENT OF SOLAR IRRADIANCE

Drummond, A. J., Hickey, J. R., Scholes, W. J.,

Laue, E. G.

AIAA 5th Aerospace Sciences Meeting, New York, January 23-26, 1967

AIAA Paper No. 67-147, pp. 1-11

For abstract, see Drummond, A. J.

Leipold, M. H.

AD11 SURFACE HYDROXYL IN MgO

Nielsen, T. H., Leipold, M. H.

Journal of The American Ceramic Society, Vol. 49, No. 11, November 21, 1966, p. 627

For abstract, see Nielsen, T. H.

Liepmann, H. W.

AD12 THEORETICAL AND EXPERIMENTAL ASPECTS OF THE SHOCK STRUCTURE PROBLEM

Liepmann, H. W., Narasimha, R., Chahine, M.

(Reprinted from *Applied Mechanics*, "Proceedings of the Eleventh International Congress of Applied Mechanics," Munich (Germany) 1966, pp. 973-979)

(Springer-Verlag, Berlin-Heidelberg-New York)

The present paper discusses essentially recent results obtained from an exact numerical solution of the Bhatnagar-Gross-Krook model. Short discussions of the Navier-Stokes and Mott-Smith theories as well as of recent experimental work are included. The main conclusions reached are the following:

(1) The B-G-K model is capable of describing the essential features of the shock layer and leads to reasonably accurate numerical values for the measurable variables.

(2) A comparison of the Chapman-Enskog approximation applied to the model and the exact solution shows that useful convergence of the C-E series requires stress to pressure ratios, τ/p , less than 0.2, corresponding to shock Mach numbers of less than about 2.

(3) The distribution function within the layer is bimodal,

exhibits the gradual change from the molecular beam-like behavior ahead to a Maxwellian distribution behind the shock. The effect of the fast molecules is noticeable even many mean paths behind the shock.

(4) The flow is nearly locally adiabatic. That is, the total enthalpy is constant to within a few percent.

Narasimha, R.

AD13 THEORETICAL AND EXPERIMENTAL ASPECTS OF THE SHOCK STRUCTURE PROBLEM
 Liepmann, H. W., Narasimha, R., Chahine, M.
 (Reprinted from *Applied Mechanics*, "Proceedings of the Eleventh International Congress of Applied Mechanics," Munich (Germany) 1966, pp. 973-979)
 (Springer-Verlag, Berlin-Heidelberg-New York)

For abstract, see Liepmann, H. W.

Nielsen, T. H.

AD14 SURFACE HYDROXYL IN MgO
 Nielsen, T. H., Leipold, M. H.
Journal of The American Ceramic Society, Vol. 49, No. 11,
 November 21, 1966, p. 627

A theoretical study was conducted of: (1) the forces holding the hydroxyl ions to the surfaces of MgO particles used to produce dense hot-pressed compacts, and (2) the amount of hydroxyl likely to be so located. The purpose was to evaluate the hydroxyl and possibly to suggest means of reducing it. The results obtained showed that, in studies affected by the defect structure of MgO, the presence of hydroxyl must be considered since normal thermal processing will yield significant quantities of it. Although MgO has a very high affinity for hydroxyl, and so might represent an extreme case, other oxides do generally reduce surface energy by gas absorption and so would be similarly affected.

Scholes, W. J.

AD15 MULTICHANNEL RADIOMETER MEASUREMENT OF SOLAR IRRADIANCE
 Drummond, A. J., Hickey, J. R., Scholes, W. J.,
 Laue, E. G.
 AIAA 5th Aerospace Sciences Meeting, New York,
 January 23-26, 1967
 AIAA Paper No. 67-147, pp. 1-11

For abstract, see Drummond, A. J.

Sharp, R. P.

AD16 PLANETARY CONTAMINATION I: THE PROBLEM AND THE AGREEMENTS
 Horowitz, N. H., Sharp, R. P., Davies, R. W.
Science, Vol. 155, No. 3769, March 24, 1967,
 pp. 1501-1505

For abstract, see Horowitz, N. H.

Vrebalovich, T.

AD17 HEAT LOSS AND RECOVERY TEMPERATURE OF FINE WIRES IN TRANSONIC TRANSITION FLOW
 Vrebalovich, T.
Rarefied Gas Dynamics, 5th Symposium, Vol. 2, 1967,
 pp. 1205-1219

This paper presents some of the results, the experimental techniques, and a discussion of the theoretical derivations and computational methods that have been used to determine the heat loss and recovery temperature of fine wires in a transonic transitional flow regime. The measurements were made over the following ranges of Mach (M), Reynolds (Re), and Knudsen (Kn) numbers:

$$0.5 \leq M \leq 1.6$$

$$0.5 < Re_T < 60$$

$$0.1 < Kn < 4$$

where Re_T is the wire Reynolds number based on wire diameter and free-stream stagnation temperature.

Wu, C.-S.

AD18 KINETIC EQUATION FOR AN INHOMOGENEOUS PLASMA IN A UNIFORM EXTERNAL MAGNETIC FIELD
 Wu, C.-S.
Proceedings of the Seventh International Conference on Phenomena in Ionized Gases, Vol. 2, Beograd 1966,
 pp. 20-23

In previous discussions of a kinetic equation for a homogeneous plasma in an external magnetic field, the distribution function was independent of spatial coordinates and was assumed to vary on a time scale much longer than the "plasma period" ($1/\omega_p$). However, in many cases the presence of high-frequency waves in the plasma makes the "homogeneous and adiabatic" model invalid. A simple derivation of a new kinetic equation without these restrictions is presented in this paper. The new equation can be applied to study transport and high-frequency wave phenomena.

AD19 UNSTABLE TRANSVERSE WAVES IN A PLASMA WITH ANISOTROPIC ION DISTRIBUTION
 Wu, C.-S.
The Physics of Fluids, Vol. 9, No. 9,
 September 1966, pp. 1852-1855

The unstable transverse waves in an anisotropic multi-component plasma are studied. Stability criteria are first established; it is then shown that the anisotropic ion distribution may result in instabilities, even if the electrons have isotropic distribution.

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